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Federal Aviation Administration

U.S. National Aviation Standard; Active Beacon Collision Avoidance System

DEPARTMENT OF TRANSPORTATION

U.S. National Aviation Standard; Active Beacon Collision Avoidance System

AGENCY: Federal Aviation Administration (FAA), Department of Transportation (DOT).

ACTION: Invitation for public comment on the Final U.S. National Aviation Standard for the Active Beacon Collision Avoidance System (BCAS).

SUMMARY: Active BCAS is a collection of airborne installations that make use of air-air transmissions for the purpose of aircraft separation assurance in low-to-medium density airspace. It is intended to satisfy the operational need for an airborne separation assurance service and to ensure compatibility with all other elements of the National Airspace System. Its operation does not depend upon the existence of any of these other elements except Air Traffic Control Radar Beacon System (ATCRBS) transponders with altitude encoders or Discrete Address Beacon System (DABS) transponders with altitude encoders in other aircraft. The standard defines the system and the performance characteristics, including technical parameters, of its subsystems. While not regulatory, the standard may provide the basis for later rule making concerning airborne collision avoidance equipment.

FOR FURTHER INFORMATION CONTACT: R. L. Bowers, Aircraft Separation Assurance Branch, ARD–244, Communications and Surveillance Division, Systems Research and Development Service, Federal Aviation Administration, Department of Transportation, Nassif Building, 400 7th Street SW., Washington, DC 20590, telephone 202–426–8432. Additional copies of this notice may be obtained from the same address.

Invitation of Public Comments

Interested persons are invited to submit written data and comments on this U.S. National Aviation Standard as they may desire. Communications should identify the notice number and be submitted in duplicate to: Director, Systems Research and Development Service, Attn: ARD–10, Federal Aviation Administration, Department of Transportation, Nassif Building, 400 7th Street SW., Washington, DC 20590, on or before February 27, 1981. Copies of comments received will be made available through ARD–10 for examination before and after the closing date for comments.

Description

The Active Beacon Collision Avoidance System is an important element of the engineering and development program for Aircraft Separation Assurance (ASA). The other elements include Full-Capability BCAS, Automatic Traffic Advisory and Resolution Service (ATARS), Conflict Alert, Conflict Resolution and Automated Terminal Service. It is intended to be a stand-alone development which is independent of the other elements of the ASA program but which will operate compatibly and cooperatively with the other elements should any or all of them be implemented. Use of the signal formats of the Discrete Address Beacon System (DABS) has been selected for BCAS to provide for high quality system communications and to allow evolutionary transition to the enhanced performance capabilities of that system when it is implemented.

History

The "Proposed U.S. National Aviation Standard for the Active Beacon Collision Avoidance System" was published in the **Federal Register** (43 FR 59565) on December 21, 1978, with a supplementary notice published in 44 FR 4920 on February 15, 1979. The BCAS National Standard has been extensively revised since that time. Changes to the standard fall into three major areas:

1. Editorial. The standard has been reorganized into the same style and sequence as used for the DABS National Standard. Additionally, most of the tutorial material has been eliminated.

2. Formats and Protocols. These have been changed to conform with the current DABS National Standard.

3. Collision Avoidance Algorithm. Certain functions of the collision avoidance algorithm have been included to ensure that the Active BCAS units interface satisfactorily with each other, with ATARS, with Full-Capability BCAS, and with the air traffic control system.

Definition of U.S. National Standard

U.S. National Aviation Standards are system standards embodying descriptions of system characteristics. They are issued by the Administrator of the Federal Aviation Administration in accordance with Section 312(c) of the Federal Aviation Act (49 USC 1353(c)). They describe the performance characteristics (the technical parameters, tolerances and techniques) of major elements of the system to the extent necessary to assure proper operation and interface compatibility among elements of the National Airspace System (NAS). U.S. National Aviation Standards generally are limited to cooperative air-to-ground subsystems involving government owned ground equipment and private airborne equipment. They are not equipment specifications or standards pertaining to planning, programming, siting, installation, availability, reliability or maintainability.

Relationship of U.S. National Aviation Standards to Federal Aviation Regulations

U.S. National Aviation Standards issued by the Administrator in agency orders are binding only on FAA organizational elements. They establish the technical basis and description of the NAS and component subsystems. A National Aviation Standard is not a standard of general or particular applicability designed to implement or prescribe law or policy. It does not fall within the definition of "rule" contained in the Administrative procedures Act (5 USC 551). There is no requirement that a National Aviation Standard be published as a notice of proposed rule making in the **Federal Register.** However, U.S. National Aviation Standards may serve as the basis for subsequent rule making actions. Accordingly, because of the relationship between the Standards and possible subsequent regulator actions, FAA publishes such Standards in the **Federal Register** and solicits public comment prior to their approval by the Administrator.

The Standard

Accordingly, the Federal Aviation Administration proposes to adopt the following BCAS Standard.

Issued in Washington, DC, on October 20, 1980.

Robert W. Wedan,

Director, Systems Research and Development Service Engineering and Development, Federal Aviation Administration Department of Transportation.

U.S. National Aviation Standard for the Active Beacon Collision Avoidance System (Final Standard for Public Comment

October 20, 1980

Systems Research and Development Service, Federal Aviation Administration, Washington, D.C. 20590

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U.S. NATIONAL AVIATION STANDARD FOR THE ACTIVE BEACON COLLISION AVOIDANCE SYSTEM

1. General.

1.1 System Features

1.1.1 The Function of Active BCAS

The Active Beacon Collision Avoidance System (Active BCAS) is a collection of airborne installations that make use of air-air beacon transmissions for the purpose of aircraft separation assurance in low-to-medium density airspace. The principal functions of a BCAS unit installed on an aircraft are:

a. Detect the presence of other aircraft flying in the vicinity and make position measurements. A BCAS unit is capable of detecting and tracking in range and altitude aircraft that are equipped with BCAS units and aircraft that are equipped with Air Traffic Control Radar Beacon System (ATCRBS) transponders with altitude encoders or Discrete Address Beacon System (DABS) transponders with altitude encoders.

b. Determine if any of these aircraft represents a collision threat.

c. Determine an appropriate aircraft vertical maneuver to resolve an encounter if a threat is detected.

d. Coordinate the maneuver decision with the other aircraft if it is also equipped with separation assurance capability so that the resulting maneuvers are compatible.

e. Communicate the maneuver decision (resolution advisory) to the pilot.

1.1.2 Rationale for the BCAS National Standard

1.1.2.1 Legal Rationale

Under Section 312(c) of the Federal Aviation Act as amended (49 U.S.C. 1353(c)), the Department of Transportation has the responsibility for the development and operation of a common system of air traffic control and navigation for both military and civil aircraft. Explicitly, the Act requires the Secretary to develop, modify, test and evaluate systems, procedures, facilities, and devices, as well as define the performance characteristics thereof, to meet the needs for safe and efficient navigation and traffic control of all civil and military aviation, except for those needs of military agencies which are peculiar to air warfare and primarily of military concern. The promulgation of a national aviation standard for Active BCAS is in keeping with this directive, as it will permit uniformity among aircraft collision avoidance systems, promoting greater efficiency and safety in aviation.

1.1.2.2 Technical Rationale

U.S. national aviation standards are system standards containing descriptions of those systems selected for implementation as a result of these developments, modifications and test and evaluation efforts. They describe system characteristics, including technical parameters that ensure proper operation and compatibility between elements of the National Airspace System.

1.2 Coordination of BCAS With Other Elements of the National Airspace System

BCAS is compatible with other existing and proposed elements of the National Airspace System, and the operation of BCAS may be automatically coordinated with the operation of these other elements.

1.2.1 Coordination With Ground Air Traffic Control

The operation of BCAS does not require ground equipment. However, where appropriate ground units are available, the operation of airborne BCAS equipment can be automatically coordinated with the air traffic control system. The DABS transponder on board the BCAS aircraft is used for communicating with DABS ground sensors and is the principal means for coordinating with ground air traffic control (ATC) in areas of DABS coverage. Where there is no DABS ground sensor, BCAS can communicate with a special unit on the ground known as an RBX. The RBX may be used for coordination with ground air traffic control facilities.

1.2.2 Coordination With the Automatic Traffic Advisory and Resolution Service

The Automatic Traffic Advisory and Resolution Service (ATARS) is a ground-based collision avoidance service which employs a DABS ground sensor for aircraft surveillance and ground-air communications. Provisions are included in the BCAS airborne equipment for coordinating with ATARS when in areas of ATARS coverage.

1.2.3 Compatibility With ATCRBS and DABS Surveillance Systems

The BCAS is designed for full operational compatibility with ATCRBS and DABS equipment. BCAS provides surveillance of both ATCRBS and DABS transponders and includes safeguards to prevent interference with the operation of ATCRBS and DABS ground surveillance systems.

1.2.4 Compatibility With ATCRBS IFF Mark XII System (AIMS)

The BCAS system is designed for full operational compatibility with AIMS including Mode 4.

1.2.5 Compatibility With Full-Capability BCAS

Full-capability BCAS (Full BCAS) is an extended Beacon Collision Avoidance System designed to operate in all airspace. It provides pilot resolution advisories both in the horizontal and vertical planes through the use of modes of operation not available in Active BCAS. Active BCAS is designed for full operational compatibility with Full BCAS.

1.3 Scope of This Standard

This document describes and standardizes those characteristics of the Active Beacon Collision Avoidance System which must be controlled to provide compatibility among components of the system and to prevent impairment of services to other users of the airspace. The document standardizes signal characteristics and coordination protocols and provides limits on radiated energy. All applications of Active BCAS messages are standardized and no experimental or ad hoc applications should be implemented without prior approval of the Federal Aviation Administration.

1.3.1 Relationship to Other U.S. National Aviation Standards

Since the BCAS interacts with other systems and subsystems which are also part of the National Airspace System, the standards governing pertinent other systems are referenced herein (1.6). In the event of conflict between this Standard and either of the referenced standards, this Standard takes lower precedence.

1.3.2 Items Not Covered

This Standard does not prescribe the detailed technical features and capabilities of Active BCAS ground or airborne equipment nor the minimum performance standards which must be met for operation in the National Airspace System. Other documentation will prescribe such minimum

performance standards for both ground-based and airborne equipment. This Standard does not in any way define or constrain the media, devices or formats for cockpit display of BCAS advisories or traffic information.

1.4 Overall System Capability

1.4.1 Coverage

The airborn BCAS equipment performs surveillance of all aircraft equipped with ATCRBS or DABS transponders and encoding altimeters within its line-of-sight coverage airspace. BCAS equipment can be designed, in accordance with this Standard, to provide serviceable coverage at air-air ranges out to 20 nmi; a particular installation may be adapted to shorter ranges to match the performance capability of the aircraft in which is is installed. Similarly, RBX equipment can provide serviceable performance at ranges out to 50 nmi, while particular installations may be adapted to shorter ranges. Serviceable coverage corresponds to a link margin of 3 dB given nominal equipment and antenna parameters.

1.4.2 BCAS Operation

BCAS alternates between DABS and ATCRBS surveillance modes. The airborne BCAS equipment may use non-directional antennas, hence surveillance data may consist of range and altitude information only. Because of this, the threat detection and resolution logic limits its resolution advisories to the vertical dimension. BCAS may use antennas with direction finding capability in generating proximity warnings (1.4.8).

1.4.3 Coordination With Other BCAS Aircraft

The availability of an air-air link allows BACS to interact with the detected aircraft if it is BCAS equipped in order to provide coordinated resoultion, thereby preventing ties in the selection of escape maneuvers.

1.4.4 Functional Elements

The principal elements of the BCAS airbourne equipment are DABS and ATCRBS surveillance subsystems, a conflict resolution logic function and a pilot display. Every BCAS aircraft has a DABS transponder to provide BCAS–BCAS maneuver coordination and to coordinate with ATARS and the RBX.

1.4.5 DABS Surveillance

The DABS surveillance subsystem detects and tracks DABS-equipped aircraft. BCAS listens to squitters and replies generated by DABS transponders in response to ground interrogations in order to determine their altitudes and DABS addresses.

After BACS has received replies from a new aircraft, it compares the altitude of the aircraft against its own altitude to determine whether the aircraft should be interrogated to determine its range. If the measured range and the reported speed capability indicate that it is or could soon be a collision threat, the aircraft is regularly interrogated and the resulting track data are fed to the conflict resolution algorithms.

1.4.6 ATCRBS Surveillance

ATCRBS surveillance is accomplished by the transmission of modified ATCRBS Mode C interrogations at regular intervals. These interrogations elicit replies from ATCRBS transponders but, to minimize interference, DABS transponders do not reply.

ATCRBS synchronous interferences may be controlled by alternating Mode C interrogations and ATCRBS suppression transmissions at varying power levels to reduce the population of ATCRBS transponders replying to each interrogation.

1.4.7 Conflict Resolution

BCAS generates the following types of resolution advisories:

a. Positive advisories.
b. Negative advisories.
c. Vertical speed limit advisories.
d. Vertical speed minimum advisories.

An advisory is generated for each aircraft whose tracked range, range rate, altitude and altitude rate indicate that its projected separation is within predefined bounds. These threat boundaries vary according to local traffic and airspace conditions. Such variations are either based on external inputs, pilot inputs, or aircraft altitude. If the threat aircraft is also BCAS or ATARS equipped, a coordination procedure is performed before displaying the advisory to the pilot to assure that the aircraft maneuvers are compatible.

1.4.8 Proximity Warnings

BCAS may generate warnings of proximate aircraft that provide the ranges, range rates, altitudes, altitude rates, and bearings of such aircraft. Proximity warnings may be provided for intruding aircraft for which resolution advisories are unnecessary or may be accompanied by resolution advisories.

1.4.9 Display

The display indicates to the pilot the advisories generated by the conflict resolution function. The BCAS display is also used for the display of Automated Traffic Advisory and Resolution Service messages received by the DABS transponder from the ground.

1.5 Acronyms and Abbreviations

1.5.1 Acronyms

ASA: Aircraft Separation Assurance
ATARS: Automatic Traffic Advisory and Resolution Service
ATC: Air Traffic Control
ATCRBS: Air Traffic Control Radar Beacon System
BCAS: Beacon Collision Avoidance System
DABS: Discrete Address Beacon System
RAR: Resolution Advisory Register
RBX: Radar Beacon Transponder

1.5.2 Abbreviations

ABS(X): absolute value of X
FPM: feet per minute
FPS^2: feet per second per second
.GE.: is greater than or equal to
.GT.: is greater than
.LE.: is less than or equal to
LSB: least significant bit
.LT.: is less than
MAX(X): the maximum of the elements of the set X
MIN(X): the minimum of the elements of the set X
MSB: most significant bit
VSL: Vertical Speed Limit
VSM: Vertical Speed Minimum

1.6 References

Reference A: "U.S. National Standard for the IFF Mark X (SIF)/Air Traffic Control Radar Beacon System Characteristics", Attachment 1 to DOT/FAA Order 1010.51A, 8 March 1971.

Reference B: "U.S. National Aviation Standard for the Discrete Address Beacon System".

Note.—A reference to paragraph 4.1 of reference B would be shown herein as ref. B: 4.1.

2. Signals In Space

2.1 RF Characteristics

The radio frequency characteristics of all signals employed by BCAS conform to either the U.S. National Aviation Standard for ATCRBS or the U.S. National Aviation Standard for DABS (ref. A or B).

3. Signal Content

Note.—The DABS National Standard (ref. B) describes the location and coding of the general information contained in DABS transmissions. This section summarizes that description for the message formats used for BCAS/ATARS/RBX messages.

3.1 Data Blocks

The interrogation and reply data blocks can contain either 56 or 112 bits.

3.2 Format Structure

DABS transmission formats consist of 56 or 112 bits of which 24 bits are used as the address while the rest are used

for information transfer. The interrogation and reply formats which can contain BCAS/ATARS/RBX information are presented in Figures 3.2–1 and 3.2–2.

3.2.1 Bit Numbering and Sequence

The bits are numbered in order of their transmission, beginning with bit 1. Numerical values are encoded with the MSB transmitted first.

3.2.2 Fields

Information is coded in fields which consist of one or more bits. In this document the decimal equivalent of the binary code formed by the bit sequence within a field is used as the designator of the field function or command.

Note.—As an example, the 5-bit UF field is used to designate the uplink format type. The surveillance interrogation with identity is designated by a UF code of 001 01. Since 001 $01_2 = 5_{10}$, this format is designated as UF=5.

3.2.2.1 Essential Fields

Each DABS transmission contains two essential fields: One describing the format and the other providing the address. The format descriptor is a 5 bit field at the beginning of the transmission and the address field always occurs at the end of the transmission. The formats are described by the UF (Uplink Format) or DF (Downlink Format) fields. The 24 bit address field carries parity information according to ref. B: 4.1. The designator is AP (Address/Parity).

3.2.2.2 Mission Fields

The remaining coding space is used to transmit the mission fields. For specific missions, a specific set of fields is prescribed.

Note.—Mission fields have two-letter designators within this Standard.

BILLING CODE 4910–13–M

Format No.	UF						
0	(0 0000)	---3---	(AQ:1)	-------23-------	(AP:24)		.Short Special Surveillance
4	(0 0100)	(PC:3)	(RR:5)	(DI:3)	(SD:16)	(AP:24)	.Surveillance, Altitude Request
5	(0 0101)	(PC:3)	(RR:5)	(DI:3)	(SD:16)	(AP:24)	.Surveillance, Identity Request
6	(0 0110)	(RD:3)	(MR:24)			(AP:24)	.Short Ground-Air Coordination
16	(1 0000)	---3---	(AQ:1)	------23--------	(MU:56)	(AP:24)	.Long Special Surveillance
20	(1 0100)	(PC:3)	(RR:5)	(DI:3)	(SD:16)	(MA:56) (AP:24)	.Comm-A, Altitude Request
21	(1 0101)	(PC:3)	(RR:5)	(DI:3)	(SD:16)	(MA:56) (AP:24)	.Comm-A, Identity Request
22	(1 0110)	(GD:3)	(MG:80)				(AP:24) .Long Ground-Air Coordination

Note: (1) (XX:M) denotes a field designated "XX" which is assigned M bits.
(2) ---N--- denotes unassigned coding space, N bits; must be set to all zeroes.
(3) The format number in the above uplink formats (UF) corresponds to the binary code in the first 5 bits of the interrogation.
(4) UF=6 is used for RBX ground-air communications, and UF=22 is used for RBX air-ground communications.

Fig. 3.2-1. DABS Interrogation or Uplink Formats Used for BCAS/ATARS/RBX Messages.

Format No.	DF							
0	(0 0000)	(MX:3)	(AQ:1)	(SL:3)	(AR:2)-1-	(AT:4)	(AC:13)	(AP:24) . . . . . Short Special Surveillance
4	(0 0100)	(FS:3)	(DR:5)	(UM:6)	(AC:13)			(AP:24) . . . . . Surveillance, Altitude
5	(0 0101)	(FS:3)	(DR:5)	(UM:6)	(ID:13)			(AP:24) . . . . . Surveillance, Identity
16	(1 0000)	(MX:3)	(AQ:1)-6-	(AT:4)	(AC:13)	(MV:56)		(AP:24) . .Long Special Surveillance
20	(1 0100)	(FS:3)	(DR:5)	(UM:6)	(AC:13)	(MB:56)		(AP:24) . .Comm-B, Altitude
21	(1 0101)	(FS:3)	(DR:5)	(UM:6)	(ID:13)	(MB:56)		(AP:24) . .Comm-B, Identity

Note: (1) (XX:M) denotes a field designated "XX" which is assigned M bits.
(2) ---N--- denotes unassigned coding space, N bits; must be set to all zeroes.
(3) The format number in the above downlink formats (DF) corresponds to the binary code in the first 5 bits of the reply.

Fig. 3.2-2. DABS Reply or Downlink Formats Used for BCAS/ATARS/RBX Messages.

BILLING CODE 4910-13-C

3.2.2.3 Subfields

Subfields may appear within mission fields.

Note.—Subfields are labelled with three-character alphanumeric designators within this Standard. Information which appears as a subset of a subfield is labelled with a four-character alphanumeric designator.

3.3 Field Descriptions

The fields and subfields which are applicable to the formats containing BCAS/ATARS/RBX information are described in this section. Fields and subfields defined by the DABS National Standard are described in 3.3.1; fields and subfields introduced by this Standard are defined in 3.3.2. Table 3.3–1 provides an index of these fields and subfields.

3.3.1 Fields and Subfields Defined by DABS National Standard

Note.—Certain coding reserved for ASA services in the DABS National Standard is further described in this section.

3.3.1.1 AC Altitude Code

Downlink, 13 bits, 20 through 32. Appears in downlink formats which report aircraft altitude (DF=0, 4, 16, 20). Coded according to pattern of ref. A: 2.7.13.2.5 and ref. A: Figure 1 if bit 26 is zero. Starting with bit 20, the sequence is C1, A1, C2, A2, C4, A4, M, B1, D1, B2, D2, B4, D4. Zero is transmitted in each of the 13 bits if altitude information is not available. Metric altitude is contained in this field if the M bit (bit 26) is set to '1'.

Note.—Metric altitude codes are not included in this Standard but may be defined in a future Standard. Currently, there is no standard metric Mode C altitude code.

3.3.1.2 AP Address/Parity

Uplink and downlink, 24 bits, 33 through 56 or 89 through 112. Appears in all formats. Parity is overlaid on the address according to ref. B: 4.1.2.

3.3.1.3 AQ Acquisition, Special

Uplink and downlink, 1 bit, 9. Appears in special surveillance formats UF=DF=0, and UF=DF=16. The code appearing in this field, when received in the uplink is repeated in the downlink. For protocol see 4.2.2.1 and 4.2.2.2.

3.3.1.4 AT ATARS

Downlink, 4 bits, 16 through 19. Appears in special surveillance formats DF=0, 16. For protocol see ref. B: 4.18.1.1.

Coding:

Bits 16 through 19 are assigned to ATARS address codes A through D sequentally; bit 16 representing site A.

BILLING CODE 4910-13-M

Table 3.3-1a
FIELD INDEX - SHEET A

Field	Sub Field	Bits No.	Bits Position	Formats Up	Formats Down	Reference Paragraph(s) Content	Reference Paragraph(s) Protocol
AC		13	20-32		X	3.3.1.1	4.2.3
AP		24	33-56 or 89-112	X	X	3.3.1.2	4.2.1;4.5.2.1; 4.5.3.1 Ref. B: 4.1.2; B: 4.2.1.1; B: 4.2.1.2
AQ		1	9	X	X	3.3.1.3	4.2.2.1;4.2.2.2 4.2.3.1;4.2.3.2 Ref. B: 4.18.1.1
AR		2	13,14		X	3.3.2.1	4.2.3
AT		4	16-19		X	3.3.1.4	4.2.3; Ref. B: 4.18.1.1
DF		5	1-5		X	3.3.1.5	4.2.1;4.2.3; 4.3.2.1;4.4.3 4.3.2.2;4.4.2.1; 4.4.2.2;4.4.4
DI		3	14-16	X		3.3.1.6	4.4.5
DR		5	9-13		X	3.3.1.7	4.4.4; Ref. B: 4.11.2; B: 4.12.2
FS		3	6-8		X	3.3.1.8	4.2.1; Ref. B: 4.5
GD		3	6-8	X		3.3.2.2	4.5.4.1
ID		13	20-32		X	3.3.1.9	
MA		56	33-88	X		3.3.1.10	
	ATARS Resolution Advisory Message subfields of MA:						4.4.1
	ADS	8	33-40			3.3.2.3.1	
	COL	14	42-55			3.3.2.3.1	
	IRA	1	41			3.3.2.3.1	
	SIT	3	86-88			3.3.2.3.1	

Table 3.3-1b
FIELD INDEX - SHEET B

Field	Sub Field	Bits No.	Bits Position	Formats Up	Formats Down	Reference Paragraph(s) Content	Reference Paragraph(s) Protocol
	ATCRBS Track Block Message subfields of MA:						4.4.1
	ADS	8	33-40			3.3.2.3.2	
	ADT	7	76-82			3.3.2.3.2	
	ALT	10	66-75			3.3.2.3.2	
	ATU	1	41			3.3.2.3.2	
	BRG	6	60-65			3.3.2.3.2	
	RDT	7	53-59			3.3.2.3.2	
	RNG	8	45-52			3.3.2.3.2	
	SEQ	3	42-44			3.3.2.3.2	
	SIT	3	86-88			3.3.2.3.2	
MB		56	33-88		X	3.3.1.11	
	Extended Capability Report subfields of MB:						4.4.3
	ACS	16	45-60			3.3.1.11.2	
	ARC	2	69-70			3.3.2.4.3	
	BDS	8	33-40			3.3.1.11.2	
	CBS	1	41			3.3.1.11.2	
	ECS	16	71-86			3.3.1.11.2	
	EDS	2	87-88			3.3.1.11.2	
	FDS	1	44			3.3.1.11.2	
	RAR Reply Message to ATARS subfields of MB:						4.4.2.1
	BDS	8	33-40			3.3.2.4.1	
	HO1	3	41-43			3.3.2.4.1	
	HO2	3	49-51			3.3.2.4.1	
	HO3	3	57-59			3.3.2.4.1	
	HO4	3	65-67			3.3.2.4.1	
	HO5	3	73-75			3.3.2.4.1	
	H06	3	81-83			3.3.2.4.1	
	VE1	5	44-48			3.3.2.4.1	
	VE2	5	52-56			3.3.2.4.1	
	VE3	5	60-64			3.3.2.4.1	
	VE4	5	68-72			3.3.2.4.1	
	VE5	5	76-80			3.3.2.4.1	
	VE6	5	84-88			3.3.2.4.1	

Table 3.3-1c
FIELD INDEX - SHEET C

Field	Sub Field	Bits No.	Bits Position	Formats Up	Formats Down	Reference Paragraph(s) Content	Reference Paragraph(s) Protocol
	RAR Busy Message to ATARS subfields of MB:						4.4.2.2
	BDS	8	33-40			3.3.2.4.2	
MG		80	9-88	X		3.3.2.5	
	BCAS-to-RBX Interrogation MG subfields:						4.5.4.1
	AID	13	15-27			3.3.2.5.1	
	ALC	13	42-54			3.3.2.5.1	
	DID	24	65-88			3.3.2.5.1	
	DRA	14	28-41			3.3.2.5.1	
	RAN	10	55-64			3.3.2.5.1	
	SLR	3	12-14			3.3.2.5.1	
MR		24	9-32	X		3.3.2.6	
	RBX Squitter subfield of MR:						4.5.2
	RAD	24	9-32			3.3.2.6.1	
	RBX Reply subfields of of MR:						4.5.3.2
	RTR	6	27-32			3.3.2.6.2	
	SLC	3	22-24			3.3.2.6.2	
MU		56	33-88	X		3.3.1.12 and 3.3.2.7	
	RAR Request and Resolution Message subfields of MU:						4.3.1;4.3.1.1;
	AR1	4	47-50			3.3.2.7.1	4.3.1.2;
	AR2	4	53-58			3.3.2.7.1	
	DID	24	65-88			3.3.2.7.1	4.3.1.2.1;
	DR1	4	43-46			3.3.2.7.1	
	DR2	4	51-54			3.3.2.7.1	
	LCK	1	41			3.3.2.7.1	
	MTB	1	42			3.3.2.7.1	
	UDS	8	33-40			3.3.2.7.1	

Table 3.3-1d
FIELD INDEX - SHEET D

Field	Sub Field	Bits No.	Bits Position	Formats Up	Formats Down	Reference Paragraph(s) Content	Reference Paragraph(s) Protocol
MV		56	33-88		X	3.3.1.13 and 3.3.2.8	
	RAR Reply Message to BCAS subfields of MV:						4.3.2.1
	HO1	3	41-43			3.3.2.8.1	
	HO2	3	49-51			3.3.2.8.1	
	HO3	3	57-59			3.3.2.8.1	
	HO4	3	65-67			3.3.2.8.1	
	HO5	3	73-75			3.3.2.8.1	
	HO6	3	81-83			3.3.2.8.1	
	VDS	8	33-40			3.3.2.8.1	
	VE1	5	41-48			3.3.2.8.1	
	VE2	5	52-56			3.3.2.8.1	
	VE3	5	60-64			3.3.2.8.1	
	VE4	5	68-72			3.3.2.8.1	
	VE5	5	76-80			3.3.2.8.1	
	VE6	5	84-88			3.3.2.8.1	
	RAR Busy Message to BCAS subfields of MV:						4.3.2.2
	VDS	8	33-40			3.3.2.8.2	
MX		3	6-9		X	3.3.1.14	4.2.3.1;4.2.3.2 Ref. B: 4.18.1.1
PC		3	6-8	X		3.3.1.15	Ref. B: 4.3; B: 4.11; B: 4.12
RD		3	6-8	X		3.3.2.9	4.5.2.1; 4.5.3.1
RR		5	9-13	X		3.3.1.16	4.4.1.1; 4.4.2.1; Ref. B: 4.2.2.1; B: 4.6.2; B: 4.6.3
SD		16	17-32	X		3.3.1.17	
	Special Designator for DI=2 (ATARS Information) subfields of SD:						4.4.5; Ref. B: 4.18
	AIS	4	17-20			3.3.1.17.1	
	RAS	1	21			3.3.1.17.1	
	SLC	3	22-24			3.3.2.10.1	
SL		3	10-12			3.3.2.11	4.2.3

Table 3.3-1e
FIELD INDEX - SHEET E

Field	Sub Field	Bits No.	Bits Position	Formats Up	Formats Down	Reference Paragraph(s) Content	Reference Paragraph(s) Protocol
UF		5	1-5	X		3.3.1.18	4.2.2; 4.3.1.1 4.3.1.2;4.4.1.1; 4.4.1.2;4.4.5; 4.5.2.1;4.5.3.1; 4.5.4.1
UM		6	14-19		X	3.3.1.19	Ref. B: 4.6.2; B: 4.7; B: 3.3.33.2

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3.3.1.5 DF Downlink Format

Downlink, 5 bits, 1 through 5. Appears in all downlink transmissions. This field is the downlink descriptor. Coding according to Fig. 3.2–2.

3.3.1.6 DI Designator, Identification

Uplink, 3 bits, 14 through 16. Appears in uplink surveillance and Comm-A formats, UF=4,5,20,21. Contains identification of coding in the SD field
Coding:
0=SD not used
1=SD contains multisite information (ref. B: 4.13.1.1)
2=SD contains ATARS information (3.3.1.17.1, 3.3.2.10.1)
3–6=not assigned
7=SD contains extended reply request (ref. B: 4.11.1.1.1)
BCAS examines the content of the SD field whenever DI=2.

3.3.1.7 DR Downlink Request

Downlink, 5 bits, 9 through 13. Appears in surveillance and Comm-B replies, DF=4,5,20,21.
Coding:
0=No downlink request
1=B bit set
2=RAR bit set
3=RAR bit set and B bit set
4–15=not assigned
16–31=see Comm-D protocol, (ref. B: 4.12.2.1)
When the RAR bit is set, i.e., RAR is non-empty, BCAS causes DR=2 or 3 to be set, as appropriate.

Note.—Requests associated with codes 1–15 take priority over requests associated with codes 16–31.

3.3.1.8 FS Flight Status

Downlink, 3 bits, 6 through 8. Appears in downlink surveillance and Comm-B formats, DF=4,5,20,21. Contains flight status.
Coding:
0=Airborne and no ALERT and no SPI
1=Airborne and no ALERT and no SIP and BCAS interrogating
2=ALERT
3=Not assigned
4=SPI
5=Not assigned
6=ALERT and SPI
7=On the ground and no ALERT and no SPI

Note.—FS=1, unless pre-empted by a higher number FS code, when BCAS operates at sensitivity levels 2 through 7. The meaning of the other codes is explained in ref. B: 4.5.

3.3.1.9 ID Identification, (4096 code)

Downlink, 13 bits, 20 through 32. Appears in downlink formats DF=5, 21 which report aircraft identification. Coded to pattern corresponding to ref. A: 2.6.

3.3.1.10 MA Message, Comm-A

Uplink, 56 bits, 33 through 88. Appears in Comm-A interrogations, UF=20,21. The MA field is used to transmit ATARS ATCRBS track block and resolution advisory information to BCAS. Contains 8-bit ADS (Comm-A Definition) subfield.

Note.—Message content and codes not related to BCAS are not included in this Standard.

3.3.1.10. Subfield in MA: ADS, A-Definition Subfield

Uplink, 8 bits, 33 through 40, subfield in MA. Defines the data contained in the remainder of MA. For convenience in coding, ADS is expressed in two groups of 4 bits each, ADS1, 33 through 36, and ADS2, 37 through 40. ADS1 defines a specific A-sink (Comm-A destination) and ADS2 defines the specific message type for that A-sink. ATARS ATCRBS track block and resolution advisory messages use ADS1=1 and 3 respectively.

3.3.1.11 MB Message, Comm-B

Downlink, 56 bits, 33 through 88. Appears in Comm-B replies, DF=20,21. The MB field is used by BCAS to transmit RAR information and extended capability reports (ref. B: 4.6.3) to the ground. Contains 8-bit BDS (Comm-B Definition) subfield.

3.3.1.11.1 Subfield in MB: BDS, B-Definition Subfield

Downlink, 8 bits, 33 through 40, subfield in MB. Defines the data contained in MB. For convenience in coding, BDS is expressed in two groups of 4 bits each, BDS1, 33 through 36, and BDS2, 37 through 40. BDS1 defines a specific B-source (Comm-B source) and BDS2 defines the specific message type from that source. Extended capability and RAR messages use BDS1=1 and 3 respectively.

3.3.1.11.2 Subfields in MB for Extended Capability Report

The following subfields defined by the DABS National Standard appear in MB for an extended capability report:
ACS: A-Capability, 16 bits, 45 through 60. Contains identity of on-board Comm-A destinations.
Coding:
To report ADS1=x, bit 45 + x is set to '1'.

Note.—BCAS aircraft must have ADS1=1 (ATARS ATCRBS track block) and ADS1=3 (ATARS resolution advisory/RAR) A-sinks on board. An A-sink is an on-board destination for long messages.
BDS: B-Definition Subfield, 8 bits, 33 through 40 (3.3.1.11.1). An extended capability report is identified by BDS1=1 and BDS2=0, the combination of which is equivalent to BDS=16.
CBS: Continuation Bit, 1 bit, 41.
Coding:
0=Capability reported only in BDS1=1, BDS2=0
1=Further capability reported in BDS1=1, BDS2.GT.0
ECS: Extended Capability, 16 bits, 71 through 86. Contains identity of on-board sources of Comm-B messages.
Coding:
To report BDS1=x, bit 71 + x is set to '1'.

Note.—BCAS aircraft must have BDS1=1 (extended capability) and BDS1=3 (RAR) B-sources on-board. A B-source is an on-board source of long messages.

EDS: ELM Description, 2 bits, 87 through 88.
Coding:
0=No ELM capability
1=Uplink ELM capability
2=Not assigned
3=Uplink and downlink ELM capability
FDS: Flight Identification, 1 bit, 44.
Coding:
0=No flight identification capability
1=Flight identification capability

Note.—A description of the remaining subfield, ARC, in MB for an extended capability report is contained in 3.3.2.4.3 because ARC is not defined in the DABS National Standard.

3.3.1.12 MU Message, Special Interrogation

Uplink, 56 bits, 33 through 88. Appears in long special surveillance interrogation, UF=16. The MU field is used by BCAS to transmit air-air coordination information.

3.3.1.13 MV Message, Special Reply

Downlink, 56 bits, 33 through 88. Appears in long special surveillance reply, DF=16. The MV field is used by BCAS (and ATARS-only aircraft) to transmit air-air coordination information.

3.3.1.14 MX Maximum Airspeed Field

Downlink, 3 bits, 6 through 8. Appears in special replies, DF=0, 16 when AQ=1. Bits 6 through 8 are free coding space when AQ=0.
Coding:
0=No data available
1=Airspeed is up to 75 knots
2=Airspeed is between 75 knots and 150 knots
3=Airspeed is between 150 knots and 300 knots
4=Airspeed is between 300 knots and 600 knots

5=Airspeed is between 600 knots and 1200 knots
6=Airspeed is more than 1200 knots
7=Aircraft is on the ground (see ref. B: 4.5.2)

The maximum true airspeed flown in normal operation is used.

3.3.1.15 PC Protocol

Uplink, 3 bits, 6 through 8. Appears in surveillance and Comm-A interrogations UF=4,5,20,21. Contains operating commands to the transponder.
Coding:
0=No action
1=General All-Call lockout (ref. B: 4.3.1)
2=Squitter lockout (ref. B: 4.3.2)
3=General All-Call lockout and squitter lockout
4=Cancel B (ref. B: 4.11.2)
5=Cancel C (ref. B: 4.12.1.3.4)
6=Cancel D (ref. B: 4.12.2.3)
7=Not assigned

3.3.1.16 RR Reply Request

Uplink, 5 bits, 9 through 13. Appears in surveillance and Comm-A interrogations, UF=4,5,20,21. Contains length and content of requested reply. The RR codes to which BCAS responds are 17 and 19.
Coding:

RR Code	Reply Length	MB Content	UM Content
17	Long	Extended Capability (ref. B: 4.6.3)	*
19	Long	RAR (4.4.2.1)	*

*The contents of UM may be specified by coding in the SD field of the interrogation. If no UM content is specified, a voluntary message may be provided (ref. B: 4.7).

Note 1.—1.If bit 1 of the RR code is a one, the last four bits of the 5-bit RR code, if transformed into their decimal equivalent, designate the number (BDS1) of the requested source.

Note 2.—2.Voluntary messages are currently undefined.

3.3.1.17 SD Special Designator

Uplink, 16 bits, 17 through 32. Appears in surveillance and Comm-A interrogations, UF=4,5,20,21. Contains control codes. Coding depends on the content of the DI field.

BCAS examines the contents of SD when DI=2 for ATARS information.

3.3.1.17.1 Subfields in SD for DI=2 (ATARS Information)

The following subfields defined by the DABS National Standard appear in SD if DI=2:

AIS: ATARS Identity, 4 bits, 17 through 20.
Coding:
0=No change in ATARS site register
1=Set ATARS site A
2=Set ATARS site B
3=Set ATARS site C
4=Set ATARS site D
5–8=Not assigned
9=Reset ATARS site A (remove site register)
10=Reset ATARS site B (remove site register)
11=Reset ATARS site C (remove site register)
12=Reset ATARS site D (remove site register)
13–15=Not assigned

RAS: Reply ATARS, 1 bit, 21.
Coding:
0=No request for ATARS register content
1=Request for ATARS register content

Note 1.—A description of the remaining subfield, SLC, in SD when DI=2 is contained in 3.3.2.10.1 because SLC is not defined in the DABS National Standard.

Note 2.—Other subfields within SD are described in ref. B: 4.11.1.1.1. and B: 4.13.1.1.

3.3.1.18 UF Uplink Format

Uplink, 5 bits, 1 through 5. Appears in all uplink transmissions. This field is the uplink descriptor. Coding according to Fig. 3.2–1.

Note.—This field uniquely identifies the structure and content of all DABS interrogations.

3.3.1.19 UM Utility Message

Downlink, 6 bits, 14 through 19. Appears in surveillance and Comm-B replies, DF=4,5,20,21. Contains requested or volunteered data (see ref. B: 4.7).

Note.—The UM field is provided in order to accomplish simple message interchanges between the aircraft and the ground. UM is not used for BCAS.

3.3.2. BCAS Fields and Subfields

Location and coding of fields and subfields required for transmission of BCAS information not specified by the DABS National Standard (ref. B) are described in alphabetical order in the following paragraphs.

3.3.2.1. AR ASA Resolution Capability Report

Downlink, 2 bits, 13 through 14. Appears in special surveillance reply format, DF=0. Contains ASA resolution capability of aircraft.
Coding:
0=No ASA resolution capability
1=ATARS only
2=Active BCAS
3=Not assigned

3.3.2.2. GD G-Definition Field

Uplink, 3 bits, 6 through 8. Appears in long ground-air coordination (RBX) interrogation format, UF=22. Defines data content and coding in the MG field.
Coding:
0=MG not used
1=MG contains Active BCAS-RBX interrogation information (3.3.2.5.1)
2–7=Not assigned.

3.3.2.3 MA Message, Comm-A

ATARS uses the MA field (3.3.1.10) of Comm-A interrogations to transmit ATARS resolution advisories and ATCRBS track blocks.

3.3.2.3.1 Subfields in MA for an ATARS Resolution Advisory Message

ADS: A-Definition Subfield, 8 bits, 33 through 40 (3.3.1.10.1). An ATARS Resolution Advisory Message is identified by ADS1=3 and ADS2=0, the combination of which is equivalent to ADS=48.

COL: ATARS Resolution Advisory Column, 14 bits, 42 through 55.
Coding:
Each bit in the COL subfield is a dedicated bit representing a specific ATARS resolution advisory. The bits in COL have the following meaning:

Bit and ATARS Resolution Advisory

42—Climb
43—Don't descend
44—Don't descend faster than 500 FPM
45—Don't descend faster than 1000 FPM
46—Don't descend faster than 2000 FPM
47—Descend
48—Don't climb
49—Don't climb faster than 500 FPM
50—Don't climb faster than 1000 FPM
51—Don't climb faster than 2000 FPM
52—Turn left
53—Turn right
54—Don't turn left
55—Don't turn right

A bit set to '1' indicates that ATARS intends the associated resolution advisory to be active (associated RAR bit set to '1'). A bit set to '0' indicates that ATARS intends the associated resolution advisory to be inactive (associated RAR bit set to '0').

IRA: Initial Resolution Advisory Bit, 1 bit, 41.

Coding:
0=Not first time resolution advisory transmitted
1=First time resolution advisory transmitted

SIT: ATARS Site ID Code, 3 bits, 86 through 88.
0=No ATARS site ID reported
1=ATARS site A
2=ATARS site B
3=ATARS site C
4=ATARS site D
5–7=Not assigned

Note.—Structure of MA for ATARS Resolution Advisory Message.

Position	Number of bits	Subfield	Remarks
33 to 36	4	ADS1	Equal 3.
37 to 40	4	ADS2	Equal 0.
41	1	IRA	
42 to 55	14	COL	
56 to 85	30		Not assigned.
86–88	3	SIT	

3.3.2.3.2 Subfields in MA for an ATCRBS Track Block Message

An ATCRBS Track Block Message describes the position of an ATCRBS-equipped aircraft in the vicinity of BCAS. The plan position of the ATCRBS aircraft is given as range and bearing from the BCAS aircraft; altitude is given relative to mean sea level (29.92 inches of Mercury).

ADS: A-Definition Subfield, 8 bits, 33 through 40 (3.3.1.10.1). An ATCRBS track block message is identified by ADS1=1 and ADS2=3, the combination of which is equivalent to ADS=19.

ADT: ATCRBS Threat Altitude Rate, 8 bits, 78 through 85.

Coding:
The altitude rate is transmitted in two's complement notation with an LSB of 2 ft/sec. The minimum and maximum values are −256 ft/sec and +254 ft/sec respectively.

ALT: ATCRBS Threat Altitude, 10 bits, 68 through 77.

Coding:
The altitude is transmitted in positive binary notation with an LSB of 100 ft. The minimum and maximum values are −1000 ft and +101,300 ft respectively.

ATU: ATCRBS Track Update Bit, 1 bit, 41.

Coding:
0=Drop track
1=Add/update ATCRBS track block

BRG: ATCRBS Threat Bearing, 6 bits, 62 through 67.

Coding:
The bearing is transmitted in two's complement notation with an LSB of 5.625°. The minimum and maximum values are −180° and +174.375° respectively. Bearing is measured positive clockwise from magnetic north.

RDT: ATCRBS Threat Range Rate, 8 bits, 54 through 61.

Coding:
The range rate is transmitted in two's complement notation and is expressed as two-way range delay per unit time with an LSB of 250 μsec/hr. The minimum and maximum values are −32,000 μsec/hr. and +31,750 μsec/hr. respectively.

Note.—All BCAS range codes are expressed in terms of two-way range delay. Nominal transponder reply delays are not included in the range delay. To obtain the one-way range, multiply the two-way range delay by c/2, where c is the speed of light. For example, using $c=3*10^8$ m/sec, a 1 μsec two-way range delay is equivalent to a range of 150 meters, and a 250 μsec/hr range delay rate is equivalent to a range rate of 37,500 meters/hr.

RNG: ATCRBS Threat Range, 9 bits, 45 through 53.

Coding:
The range is transmitted in positive binary notation and is expressed as two-way range delay with an LSB of 1 μsec. The minimum and maximum values are 0 μsec and 511 μsec respectively. Any range greater than 511 μsec is expressed as 511 μsec.

SEQ: ATARS Track Sequence Number, 3 bits, 42 through 44.

Coding:
The decimal equivalent of the binary code formed by the bit sequence of the SEQ subfield denotes the track sequence number.

SIT: ATARS Site ID Code, 3 bits, 86 through 88.

Coding:
0=No ATARS site ID reported
1=ATARS site A
2=ATARS site B
3=ATARS site C
4=ATARS site D
5–7=Not assigned

Note.—Structure of MA for ATCRBS Track Block Message.

Position	Number of bits	Subfield	Remarks
33 to 36	4	ADS1	Equal 1
37 to 40	4	ADS2	Equal 3.
41	1	ATU	
42 to 44	3	SEQ	
45 to 53	9	RNG	
54 to 61	8	RDT	
62 to 67	6	BRG	
68 to 77	10	ALT	
78 to 85	8	ADT	
86 to 88	3	SIT	

3.3.2.4 MB Message, Comm-B

BCAS uses the MB field (3.3.1.11) of Comm-B replies to transmit to the ground sensor (ATARS) and RAR Reply Message to ATARS, an RAR Busy Message to ATARS and an extended capability report. The technique for encoding the RAR Reply Message to ATARS is described in 5.2.3.3.

3.3.2.4.1 Subfields in MB for an RAR Reply Message to ATARS

BDS: B-Definition Subfield, 8 bits, 33 through 40 (3.3.1.11.1). An RAR Reply Message to ATARS is identified by BDS1=3 and BDS2=0, the combination of which is equivalent to BDS=48.

HO1: RAR Column 1 Horizontal Advisories, 3 bits, 41 through 43. Contains the horizontal resolution advisories set (if any) in column 1 (ATARS site A column) of the RAR.

Coding:
0=No horizontal resolution advisories
1=Not assigned
2=Turn left
3=Turn right
4=Don't turn left
5=Don't turn right
6=Not assigned
7=Don't turn left and don't turn right

HO2: RAR Column 2 Horizontal Advisories, 3 bits, 49 through 51. Contains the horizontal resolution advisories set (if any) in column 2 (ATARS site B column) of the RAR.

Coding:
As specified for HO1.

HO3: RAR Column 3 Horizontal Advisories, 3 bits, 57 through 59. Contains the horizontal resolution advisories set (if any) in column 3 (ATARS site C column) of the RAR.

Coding:
As specified for HO1.

HO4: RAR Column 4 Horizontal Advisories, 3 bits, 65 through 67. Contains the horizontal resolution advisories set (if any) in column 4 (ATARS site D column) of the RAR.

Coding:
As specified for HO1.

HO5: RAR Column 5 Horizontal Advisories, 3 bits, 73 through 75. Contains the horizontal resolution advisories set (if any) in column 5 (Own BCAS column) of the RAR.

Coding:
As specified for HO1.

HO6: RAR Column 6 Horizontal Advisories, 3 bits, 81 through 83. Contains the horizontal resolution advisories set (if any) in column 6 (All other BCAS column) of the RAR.

Coding:
As specified for HO1.

VE1: RAR Column 1 Vertical Advisories, 5 bits, 44 through 48. Contains the vertical resolution advisories set (if any) in column 1 (ATARS site A column) of the RAR.

Coding:
0=No vertical resolution advisories
1–3=Not assigned
4=Don't descend
5=Don't descend faster than 500 FPM
6=Don't descend faster than 1000 FPM
7=Don't descend faster than 2000 FPM
8=Don't climb
9=Don't climb faster than 500 FPM
10=Don't climb faster than 1000 FPM
11=Don't climb faster than 2000 FPM
12=Not assigned
13=Climb
14=Not assigned
15=Descend
16=Don't descend and don't climb
17=Don't descend and don't climb faster than 500 FPM
18=Don't descend and don't climb faster then 1000 FPM
19=Don't descend and don't climb faster than 2000 FPM
20=Don't descend faster than 500 FPM and don't climb
21=Don't descend faster than 500 FPM and don't climb faster than 500 FPM
22=Don't descend faster than 500 FPM and don't climb faster than 1000 FPM
23=Don't descend faster than 500 FPM and don't climb faster than 2000 FPM
24=Don't descend faster than 1000 FPM and don't climb
25=Don't descend faster than 1000 FPM and don't climb faster than 500 FPM
26=Don't descend faster than 1000 FPM and don't climb faster than 1000 FPM
27=Don't descend faster than 1000 FPM and don't climb faster than 2000 FPM
28=Don't descend faster than 2000 FPM and don't climb faster than 500 FPM
30=Don't descend faster than 2000 FPM and don't climb faster than 1000 FPM
31=Don't descend faster than 2000 FPM and don't climb faster than 2000 FPM.

VE2: RAR Column 2 Vertical Advisories, 5 bits, 52 through 56. Contains the horizontal resolution advisories set (if any) in column 2. (ATARS site B column) of the RAR.

Coding:
As specified for VEI.

VE3: RAR Column 3 Vertical Advisories, 5 bits, 60 through 64. Contains the vertical resolution advisories set (if any) in column 3 (ATARS site C column) of the RAR.

Coding:
As specified for VE1.

VE4: RAR Column 4 Vertical Advisories, 5 bits, 68 through 72. Contains the vertical resolution advisories set (if any) in column 4 (ATARS site D column) of the RAR.

Coding:
As specified for VE1.

VE5: RAR Column 5 Vertical Advisories, 5 bits, 76 through 80. Contains the vertical resolution advisories set (if any) in column 5 (Own BCAS column) of the RAR.

Coding:
As specified for VE1.

VE6: RAR Column 6 Vertical Advisories, 5 bits, 84 through 88. Contains the vertical resolution advisories set (if any) in column 6 (All Other BCAS column) of the RAR.

Coding:
As specified for VE1.

Note 1.—Structure of MB for RAR Reply Message to ATARS.

Position	Number of bits	Subfield	Remarks
33 to 36	4	BDS1	Equal 3.
37 to 40	4	BDS2	Equal 0.
41 to 43	3	HO1	
44 to 48	5	VE1	
49 to 51	3	HO2	
52 to 56	5	VE2	
57 to 59	3	HO3	
60 to 64	5	VE3	
65 to 67	3	HO4	
68 to 72	5	VE4	
73 to 75	3	HO5	
76 to 80	5	VE5	
81 to 83	3	HO6	
84 to 88	5	VE6	

Note 2.—An RAR Reply Message to ATARS with all HOx and VEx subfields containing all zeroes implies an empty RAR.

3.3.2.4.2. Subfields in MB for an RAR Busy Message to ATARS

BDS: B-Definition Subfield, 8 bits, 33 through 40 (3.3.1.11.1). An RAR Busy Message to ATARS is identified by BDS1=3 and BDS2=1, the combination of which is equivalent to BDS=49.

Note.—Structure of MB for RAR Busy Message to ATARS.

Position	Number of bits	Subfield	Remarks
33 to 36	4	BDS1	Equal 3.
37 to 40	4	BDS2	Equal 1.
41 to 88	48		Not assigned.

3.3.2.4.3 Subfield in MB for Extended Capability Report

The following subfield appears in MB for an extended capability report:

ARC: ASA Resolution Capability, 2 bits, 69 through 70. Contains ASA resolution capability of aircraft.

Coding:
0=No ASA resolution capability
1=ATARS only
2=Active BCAS
3=Not assigned

Note.—Structure of MB for Extended Capability Report.

Position	Number of bits	Subfield	Remarks
33 to 36	4	BDS1	Equal 1
37 to 40	4	BDS2	Equal 0.
41	1	CBS	
42 to 43	2		Not assigned.
44	1	FDS	
45 to 60	16	ACS	
61 to 68	8		Not assigned.
69 to 70	2	ARC	
71 to 86	16	ECS	
87 to 88	2	EDS	

The ACS, BDS1, BDS2, CBS, ECS, EDS and FDS subfields are described in 3.3.1.11.2.

3.3.2.5 MG Message, Long Ground-Air Coordination (RBX) Interrogation

Uplink, 80 bits, 9 through 88. Appears in long ground-air coordination (RBX) interrogation format, UF=22. Contains BCAS–RBX interrogation information. Data content and coding depend on the content of the GD field (3.3.2.2).

3.3.2.5.1 Subfields in MG for Active BCAS–RBX Interrogation Message

The following subfields appear in MG if GD=1:

AID: ATCRBS Identification, 13 bits, 15 through 27. Contains ATCRBS mode A identification code (4096 code) of

interrogating BCAS aircraft. Coded to pattern corresponding to ref. A: 2.6.

ALC: Altitude Code, 13 bits, 42 through 54. Coded according to pattern of ref. A: 2.7.13.2.5 and ref. A: Figure 1, if bit 48 is zero. Starting with bit 42, the sequence is C1, A1, C2, A2, C4, A4, M, B1, D1, B2, D2, B4, D4. Zero is transmitted in each of the 13 bits if altitude information is not available. Metric altitude is contained in this field if the M bit (bit 48) is set to '1'.

DID: DABS Address, 24 bits, 65 through 88. Contains discrete address of interrogating BCAS aircraft.

DRA: Displayed Resolution Advisory, 14 bits, 28 through 41. Contains resolution advisory displayed to pilot (5.2.3.5.2).

Coding:

Each bit in the DRA subfield is a dedicated bit which, when set to '1', identifies a particular resolution advisory component displayed to the pilot. A bit set to '0' indicates that the resolution advisory component associated with that bit is not displayed. When set to '1', each bit has the following meaning:

Bit	Active resolution advisory component
28	Climb.
29	Don't descend.
30	Don't descend faster than 500 FPM.
31	Don't descend faster than 1000 FPM.
32	Don't descend faster than 2000 FPM.
33	Descend.
34	Don't climb.
35	Don't climb faster than 500 FPM.
36	Don't climb faster than 1000 FPM.
37	Don't climb faster than 2000 FPM.
38	Turn left.
39	Turn right.
40	Don't turn left.
41	Don't turn right.

Note.—A DRA subfield set to all zeroes indicates no resolution advisory is being displayed to the pilot.

RAN BCAS to RBX Range, 10 bits, 55 through 64.

Coding:

The range is transmitted in positive binary notation and is expressed as two-way range delay with an LSB of 2 μsec. The minimum and maximum values are 0 μsec and 2044 μsec respectively. The RAN field in the initial (acquisition) BCAS to RBX interrogation is set to all ones to indicate that no data are available.

Note.—An RAN field set to all ones causes the RBX to reply with the SLC field set to the zero code (3.3.2.6.2).

SLR: Sensitivity Level Command Report, 3 bits, 12 through 14. Contains the last sensitivity level command received from the RBX to which this interrogation is addressed.

Coding:

0=No sensitivity level received
1=Last sensitivity level command received: set to level 1
2=Last sensitivity level command received: set to level 2
3=Last sensitivity level command received: set to level 3
4=Last sensitivity level command received: set to level 4
5=Last sensitivity level command received: set to level 5
6=Last sensitivity level command received: set to level 6
7=Last sensitivity level command received: set to level 7

Note.—Structure of MG for Active BCAS-RBX Interrogation Message.

Position	Number of bits	Subfield	Remarks
9 to 11	3		Not assigned.
12 to 14	3	SLR	
15 to 27	13	AID	
28 to 41	14	DRA	
42 to 54	13	ALC	
55 to 64	10	RAN	
65 to 88	24	DID	

3.3.2.6 MR Message, Short Ground-Air Coordination Interrogation

Uplink, 24 bits, 9 through 32. Appears in short ground-air coordination (RBX) interrogation format, UF=6. The MR field is used to transmit RBX squitter and reply information to BCAS. Data content and coding depend on the content of the RD field (3.3.2.9).

3.3.2.6.1 Subfields in MR for an RBX Squitter

The following subfield appears in MR if RD=1.

RAD: RBX Address, 24 bits, 9 through 32. Contains discrete address of RBX unit.

Note.—Structure of MR for RBX Squitter Message.

Position	Number of bits	Subfield	Remarks
9 to 32	24	RAD	

3.3.2.6.2 Subfields in MR for an RBX Reply

The following subfields appear in MR if RD=2.

RTR: RBX Threshold Range, 6 bits, 27 through 32.

Coding:

RTR is transmitted in positive binary notation and is expressed as two-way range delay with an LSB of 16 μsec. The minimum and maximum values are 0 μsec and 1008 μsec respectively.

SLC: BCAS Sensitivity Level Command, 3 bits, 22 through 24.

Coding:

0=No command issued
1=Set BCAS sensitivity level to 1
2=Set BCAS sensitivity level to 2
3=Set BCAS sensitivity level to 3
4=Set BCAS sensitivity level to 4
5=Set BCAS sensitivity level to 5
6=Set BCAS sensitivity level to 6
7=Set BCAS sensitivity level to 7

Note 1.—In an initial RBX Reply, SCL=0
Note 2.—Strutrue of MR for RBX reply message.

Position	Number of bits	Subfield	Remarks
9 to 21	13		Not assigned.
22 to 24	3	SLC	
25 to 26	2		Not assigned.
27 to 32	6	RTR	

3.3.2.7 MU Message, Special Interrogation

BCAS uses the MU field (3.3.1.12) of a long special surveillance interrogation for air-air coordination. The RAR Request Message and the Resolution Message share a common MU message format and are distinguished by the setting of the LCK subfield (see 3.3.2.7.1).

3.3.2.7.1 Subfields in MU for an RAR Request Message and Resolution Message

AR1: Add Resolution Advisory, 4 bits, 47 through 50. Contains the complement (don't climb or don't descend) of own resolution advisory chosen with respect to the interrogated threat to be added to the "All Other BCAS" column of the threat RAR.

Coding:

0=No complement to be added
1=Not assigned
2=Don't descend
3–6=Not assigned
7=Don't climb
8–15=Not assigned

AR2: Add Resolution Advisory, 4 bits, 55 through 58. This field is used by Full BCAS to post horizontal maneuver restrictions in the RAR of Active BCAS airborne equipments. Such restrictions are processed by Active BCAS while updating the RAR with ATARS resolution advisories (5.2.3.1.3.). In RAR Request Messages and Resolution Messages transmitted by Active BCAS, AR2 is set to all zeroes to indicate no message.

Coding:
0=No complement to be added
1–12=Not assigned
13=Don't turn left
14=Don't turn right
15=Not assigned

DID: DABS address, 24 bits, 65 through 88. Contains discrete address of interrogating BCAS aircraft.

DR1: Delete Resolution Advisory, 4 bits, 43 through 46. Contains the complement of own resolution advisory chosen with respect to the interrogated threat to be deleted from the "All Other BCAS" column of the threat RAR.

Coding:
0=No complement to be deleted
1=Not assigned
2=Don't descend
3–6=Not assigned
7=Don't climb
8–15=Not assigned

DR2: Delete Resolution Advisory, 4 bits, 51 through 54. This field is used by Full BCAS to post horizontal maneuver restrictions in the RAR of Active BCAS airborne equipments. Such restrictions are processed by Active BCAS while updating the RAR with ATARS resolution advisories (5.2.3.1.3.). In RAR Request Messages and Resolution Messages transmitted by Active BCAS, DR2 is set to all zeroes to indicate no message.

Coding:
0=No complement to be deleted
1–12=Not assigned
13=Don't turn left
14=Don't turn right
15=Not assigned

LCK: Extended RAR Lock Bit, 1 bit, 41. When set to '1', LCK instructs the interrogated BCAS aircraft to lock its RAR and maintain the lock state until a second coordination interrogation (Resolution Message) is received.

Coding:
0=Do not maintain RAR lock state for a second coordination interrogation.
1=Maintain RAR lock state until a second coordination interrogation is received.

Note.—The LCK subfield implicitly distinguishes an RAR Request Message from a Resolution Message because LCK is always set to '1' in an RAR Request Message while it is always set to '0' in a Resolution Message.

MTB: Multiple Threat Bit, 1 bit, 42.

Coding:
0=Interrogating BCAS has no more than one threat
1=Interrogating BCAS has more than one threat

UDS: U-Definition Subfield, 8 bits, 33 through 40. Defines the data content and coding in the remainder of MU.

For convenience in coding, UDS is expressed in two groups of 4 bits each, UDS1, 33 through 36, and UDS2, 37 through 40. UDS1 defines the destination of the MU message and UDS2 defines the specific message type.

RAR Request Messages and Resolution Messages are identified by UDS1=3 (RAR) and UDS2=1, the combination of which is equivalent to UDS=49.

Note.—Structure of MU for RAR Request Message and Resolution Message.

Position	Number of bits	Subfield	Remarks
33 to 36	4	UDS1	Equal 3.
37 to 40	4	UDS2	Equal 1.
41	1	LCK	
42	1	MTB	
43 to 46	4	DR1	
47 to 50	4	AR1	
51 to 54	4	DR2	
55 to 58	4	AR2	
59 to 64	6		Not assigned.
65 to 88	24	DID	

3.3.2.8 MV Message, Special Reply

BCAS uses the MV field of a long special surveillance reply (3.3.1.13) to transmit to another BCAS aircraft either an RAR Reply Message to BCAS or an RAR Busy Message to BCAS.

3.3.2.8.1 Subfields in MV for an RAR Reply Message to BCAS

The technique for encoding the RAR Reply Message to BCAS is described in 5.2.3.2.3.

H01: RAR Column 1 Horizontal Advisories, 3 bits, 41 through 43. Contains the horizontal resolution advisories set (if any) in column 1 (ATARS site A column) of the RAR.

Coding:
As specified for H01 in 3.3.2.4.1.

H02: RAR Column 2 Horizontal Advisories, 3 bits, 49 through 51. Contains the horizontal resolution advisories set (if any) in column 2 (ATARS site B column) of the RAR.

Coding:
As specified for H01 in 3.3.2.4.1.

H03: RAR Column 3 Horizontal Advisories, 3 bits, 57 through 59. Contains the horizontal resolution advisories set (if any) in column 3 (ATARS site C column) of the RAR.

Coding:
As specified for H01 in 3.3.2.4.1.

H04: RAR Column 4 Horizontal Advisories, 3 bits, 65 through 67. Contains the horizontal resolution advisories set (if any) in column 4 (ATARS site D column) of the RAR.

Coding:
As specified for H01 in 3.3.2.4.1.

H05: RAR Column 5 Horizonatal Advisories, 3 bits, 73 through 75. Contains the horizontal resolution advisories set (if any) in column 5 (Own BCAS column) of the RAR.

Coding:
As specified for H01 in 3.3.2.4.1.

H06: RAR Column 6 Horizontal Advisories, 3 bits, 81 through 83. Contains the horizontal resolution advisories set (if any) in column 6 (All Other BCAS column) of the RAR.

Coding:
As specified for H01 in 3.3.2.4.1.

VDS: V-Definition Subfield, 8 bits, 33 through 40. Defines the data content and coding in the remainder of MV. For convenience in coding, VDS is expressed in two groups of 4 bits each, VDS1, 33 through 36, VDS2, 37 through 40. VDS1 defines the source of the MV message and VDS2 defines the specific message type from that source.

An RAR Reply Message to BCAS is identified by VDS1=3 (RAR) and VDS2=0, the combination of which is equivalent to VDS=48.

VE1: RAR Column 1 Vertical Advisories, 5 bits, 44 through 48. Contains the vertical resolution advisories set (if any) in column 1 (ATARS site A column) of the RAR.

Coding:
As specified for VE1 in 3.3.2.4.1.

VE2: RAR Column 2 Vertical Advisories, 5 bits, 52 through 56. Contains the vertical resolution advisories set (if any) in column 2 (ATARS site B column) of the RAR.

Coding:
As specified for VE1 in 3.3.2.4.1.

VE3: RAR Column 3 Vertical Advisories, 5 bits, 60 through 64. Contains the vertical resolution advisories set (if any) in column 3 (ATARS site C column) of the RAR.

Coding:
As specified for VE1 in 3.3.2.4.1.

VE4: RAR Column 4 Vertical Advisories, 5 bits, 68 through 72. Contains the vertical resolution advisories set (if any) in column 4 (ATARS site D column) of the RAR.

Coding:
As specified for VE1 in 3.3.2.4.1.

VE5: RAR Column 5 Vertical Advisories, 5 bits, 76 through 80. Contains the vertical resolution advisories (if any) in column 5 (Own BCAS column) of the RAR.

Coding:
As specified for VE1 in 3.3.2.4.1.

VE6: RAR Column 6 Vertical Advisories, 5 bits, 84 through 88. Contains the vertical resolution advisories set (if any) in column 6 (All Other BCAS column) of the RAR.

Coding:
As specified for VE1 in 3.3.2.4.1.

Note 1: Structure of MV for RAR Reply Message to BCAS.

Position	Number of bits	Subfield	Remarks
33 to 36	4	VDS1	Equal 3.
37 to 40	4	VDS2	Equal 0.
41 to 43	3	H01	
44 to 48	5	VE1	
49 to 51	3	H02	
52 to 56	5	VE2	
57 to 59	3	H03	
60 to 64	5	VE3	
65 to 67	3	H04	
68 to 72	5	VE4	
73 to 75	3	H05	
76 to 80	5	VE5	
81 to 83	3	H06	
84 to 88	5	VE6	

The structure of the MV field for an RAR Reply Message to BCAS is identical to the structure of the MB field for an RAR Reply Message to ATARS (3.3.2.4.1).

Note 2.—An RAR Reply Message to BCAS with all H0x and VEx subfields containing all zeroes implies an empty RAR.

3.3.2.8.2 Subfields in MV for an RAR Busy Message to BCAS.

VDS: V-Definition Subfield, 8 bits, 33 through 46 (3.3.2.8.1). An RAR Busy Message to BCAS is identified by VSD1=3 (RAR) and VDS2=1, the combination of which is equivalent to VDS=49.

Note.—Structure of MV for RAR Busy Message to BCAS.

Position	Number of bits	Subfield	Remarks
33 to 36	4	VDS1	Equal 3.
37 to 40	4	VDS2	Equal 1.
41 to 88	48		Not assigned.

The structure of the MV field for an RAR Reply Message to BCAS is identical to the structure of the MB field for an RAR Busy Message to ATARS (3.3.2.4.2).

3.3.2.9 RD R—Defintion Field

Uplink, 3 bits, 6 through 8. Appears in short ground-air coordination (RBX) interrogation format, UF=6. Defines data content and coding in the MR field.
Coding:
0=MR not used
1=MR contains RBX squitter information (3.3.2.6.1)
2=MR contains RBX reply information (3.3.2.6.2)
3–7=Not assigned

3.3.2.10 SD Special Designator

Ground ATARS equipment uses the SD field format associated with the DI=2 code (3.3.1.17.1) of surveillance and Comm-A interrogations to transmit to BCAS a senstivitiy level command.

3.3.2.10.1 Subfield in SD for DI=2 (ATARS Information)

The following subfield appears in SD if DI=2.
SLC: BCAS Sensitivity Level Command, 3 bits, 22 through 24.
Coding:
0=No command issued
1=Set BCAS sensitivity level to 1
2=Set BCAS sensitivity level to 2
3=Set BCAS sensitivity level to 3
4=Set BCAS sensitivity level to 4
5=Set BCAS sensitivity level to 5
6=Set BCAS sensitivity level to 6
7=Set BCAS sensitivity level to 7

Note.—Structure of SD for DI=2 (ATARS Information).

Position	Number of bits	Subfield	Remarks
17 to 20	4	AIS	
21	1	RAS	
22 to 24	3	SLC	
25 to 32	8		Not assigned.

The AIS and RAS subfields are described in 3.3.1.17.1.

3.3.2.11 SL BCAS Sensitivity Level Report

Downlink, 3 bits, 10 through 12. Appears in short special surveillance reply, DF=0. Contains sensitivity level at which BCAS aircraft is currently operating.
Coding:
0=No BCAS sensitivity level reported
1=BCAS is operating at sensitivity level 1
2=BCAS is operating at sensitivity level 2
3=BCAS is operating at sensitivity level 3
4=BCAS is operating at sensitivity level 4
5=BCAS is operating at sensitivity level 5
6=BCAS is operating at sensitivity level 6
7=BCAS is operating at sensitivity level 7

Note.—A DABS aircraft with no ASA capability (AR=0) or which is only ATARS equipped (AR=1) causes SL to be set to the zero code.

3.3.2.12 Unassigned Coding Space

Unassigned coding space as indicated in Figures 3.2–1 and 3.2–2 contains all zeroes as transmitted by interrogators and transponders. Coding space currently unassigned is reserved for possible future use.

Note.—This rule assures that future assignments in this coding space define a "zero-block" as a default code, i.e., no message is sent and/or no capability exists.

4. Protocol

4.1 ATCRBS Surveillance.

4.1.1 ATCRBS Interrogation.

4.1.1.1 ATCRBS-Only All-Call.

For surveillance of aircraft equipped with ATCRBS transponders, the ATCRBS-Only All-Call interrogation is used (ref. B: 2.3.2).

Note 1.—This interrogation format causes all ATCRBS-equipped aircraft to reply and all DABS-equipped aircraft to not reply. The absence of replies from DABS transponders is desirable since such replies are unnecessary and would add to the interference environment. Absence of these replies from the BCAS synchronous interference environment is particularly beneficial.

Note 2.—An ATCRS-Only All-Call can be in mode A or mode C. A BCAS transmits mode C interrogations and thereby obtains range and altitude surveillance information. Mode A interrogations may also be used, but these are not necessary for basic range and altitude surveillance.

4.1.1.2 Control of Synchronous Interference

To control ATCRBS synchronous interference and facilitate BCAS operation in airspace with higher traffic densities, a feature called "whisper-shout" may be used. In this feature, a single interrogation is replaced by a sequence of interrogations at different power levels. Each of these interrogations, other than the one at lowest power, is preceded by a suppression pair (a pair of pulses spaced by 2 μs, with characteristics the same as the 2-pulse SLS control transmission defined in ref. A: 2.4.4). The suppression pair is transmitted at a power level lower than that of the accompanying interrogation. The suppression pair begins at a time 4 $\pm$ 1 μs before the beginning of the interrogation.

Note.—Figure 4.1–1 shows an example of a whisper-shout sequence with 4 interrogations from the top antenna and 4 interrogations from the bottom antenna. The four power levels are spaced uniformly by 6 dB, and each suppression pair is 8 dB below its accompanying interrogation. The intended mechanism is that each aircraft replies to one or at most two of the four interrogations in a group. Given a situation in which multiple aircraft are near enough in range to synchronously interfere with each other, it is likely they do not all reply to the same interrogation, and as a result the severity of synchronous interference is reduced. Use of whisper-shout has additional benefits in reducing the severity of the effects of multipath on the interrogation link.

BILLING CODE 4910-13-M

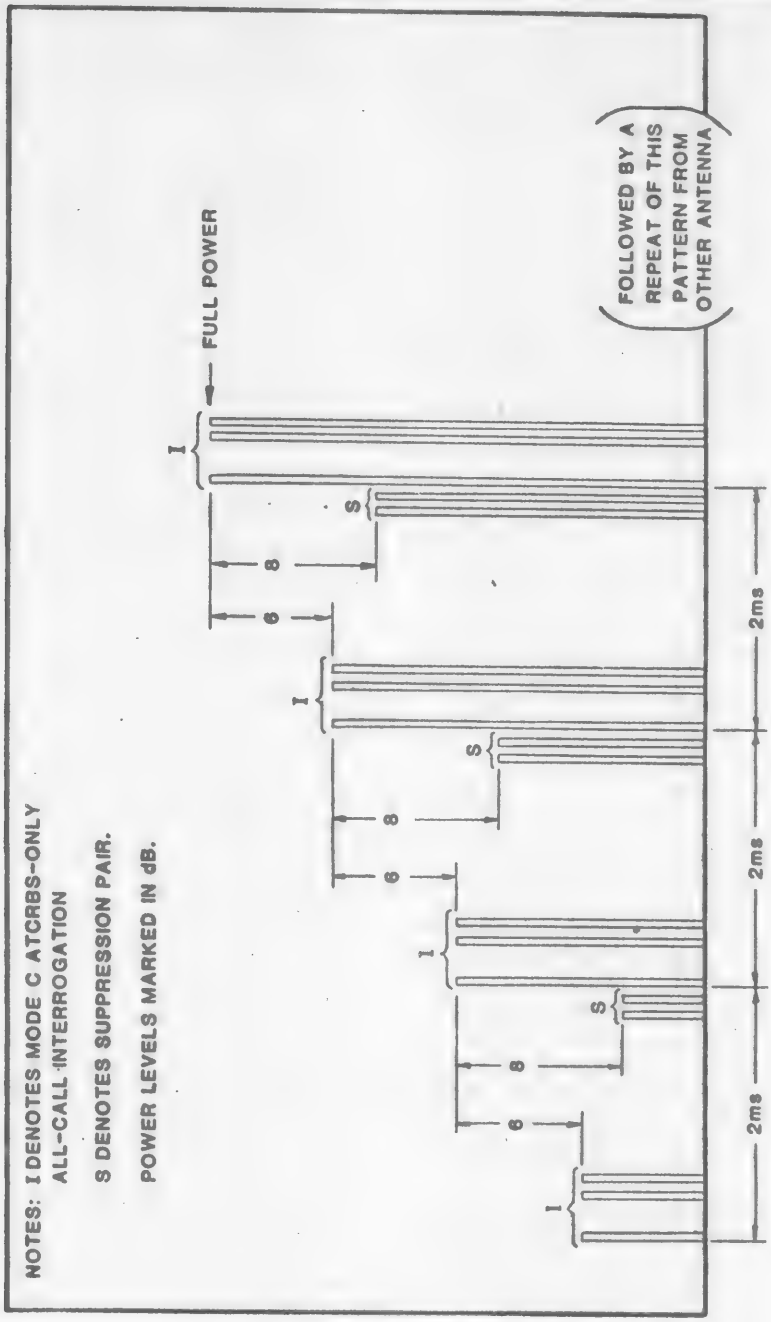

FIG. 4.1-1. EXAMPLE OF WHISPER-SHOUT SEQUENCE.

BILLING CODE 4910-13-C

4.2 DABS Surveillance

Note.—This section describes the interactions between the airborne BCAS and a DABS-equipped aircraft required for the proper functioning of the BCAS DABS surveillance tasks.

4.2.1 Detection

BCAS detects the presence of DABS equipped aircraft by listening at 1090 MHz, to transmissions containing altitude data, DF=4. These DABS transponder transmissions may occur in response to ground sensor discrete interrogations or as squitters.

BCAS derives the discrete address and altitude of the DABS aircraft from the AP and AC field, respectively. Additionally, BCAS examines the Flight Status, FS, field in these transmissions to determine if the other carrier has an interrogating BCAS (FS=1) or is on the ground (FS=7).

Note 1.—The fact that the other DABS aircraft has an interrogating BCAS is used as input into the computation of permissible interrogation rates (5.1.2).

Note 2.—If the other DABS aircraft is on the ground, BCAS does not need to track it.

4.2.2 Surveillance Interrogations

The response to the initial detection of a near-coaltitude DABS aircraft is a range acquisition interrogation, UF=0. When the range, altitude, and maximum speed capabilities of the BCAS aircraft and the detected DABS aircraft indicate that the detected aircraft is or could soon become a collision threat, periodic interrogations of the DABS aircraft are made using a short special surveillance interrogation, UF=0. Otherwise, interrogations to the DABS aircraft are temporarily suspended.

4.2.2.1 Acquisition

BCAS sets AQ=1 (3.3.1.3) in the short surveillance interrogation, UF=0, when a DABS aircraft is undergoing range acquisition. This serves as an aid in distinguishing the reply to own interrogation from replies elicited by other BCAS units.

4.2.2.2 Roll Call

BCAS sets AQ=0 (3.3.1.3) in the short special surveillance interrogation, UF=0, when a track has been established for a DABS aircraft.

4.2.3 Surveillance Replies

On receipt of a short special interrogation, UF=0, from a BCAS, a DABS transponder replies with a short special surveillance reply, DF=0. In this reply, the altitude, the contents of the ATARS site register, and the ASA capability of the aircraft are reported in the AC (3.3.1.2), AT (3.3.1.5) and AR (3.3.2.1) fields respectively. If the AR field is set to 2, indicating an Active BCAS capability, the SL field (3.3.2.11) further specifies the sensitivity level at which the BCAS is operating (5.2.4). If AR=0 or 1, the SL field has no meaning and is set to all zeroes.

4.2.3.1 Acquisition

On receipt of a short special surveillance interrogation with the AQ field set to "1", the AQ field of the reply is correspondingly set to "1" by a DABS transponder indicating a range acquisition reply. The maximum airspeed is reported by a DABS transponder in the MX field (3.3.1.14) of an acquisition reply.

4.2.3.2 Roll Call

On receipt of a short special surveillance interrogation with the AQ field set to "0", the AQ field of the reply is correspondingly set to "0" by a DABS transponder indicating a roll-call reply.

4.3 Coordination With Other Aircraft

Note.—This section describes the interactions between the airborne BCAS and a BCAS or ATARS equipped aircraft required for the proper functioning of the BCAS air-air conflict resolution coordination tasks.

4.3.1 BCAS Coordination Interrogations

When BCAS declares another BCAS or ATARS equipped aircraft to be a collision threat, interrogations to it are initiated for conflict resolution coordination (5.2.3.2). Coordination interrogations are periodically made to the other aircraft as long as it remains a collision threat. Two types of BCAS coordination interrogations are transmitted; an RAR Request Message and a Resolution Message. For a newly declared threat, the coordination sequence involves first sending an RAR Request Message and then a Resolution Message. For an established threat, the coordination sequence involves sending only a Resolution Message.

4.3.1.1 RAR Request Message.

An RAR Request Message (5.2.3.2.1) uses the long special surveillance interrogation, UF=16, with the MU field containing the subfields specified in 3.3.2.7.1 and contains the codes:

AR1=0 (no complement to be added)
DR1=0 (no complement to be deleted)
LCK=1 (interrogated BCAS to keep RAR locked for receipt of second coordination interrogation).

4.3.1.2 Resolution Message

A Resolution Message (5.2.3.2.2) uses the long special surveillance interrogation, UF=16, with the MU field containing the subfields specified in 3.3.2.7.1 and contains the code:

LCK=0 (interrogated aircraft to unlock its RAR after processing this interrogation).

4.3.1.2.1 New Threat

A Resolution Message is transmitted as the second of a two-coordination interrogation sequence to a new threat. The Resolution Message contains in AR1 the complement to be added to the threat's RAR. DR1 is set to the zero code.

4.3.1.2.2 Established Threat

Coordination with established threats and with aircraft that have changed from a threat status to a non-threat status (dropped threats) involves only a single transaction, that is, transmission of a Resolution Message. The complements (if any) to be added (or continued) and/or deleted in the threat's RAR are coded in AR1 and DR1 respectively.

4.3.2 Coordination Replies to BCAS

Upon acceptance of a BCAS coordination interrogation, the threat aircraft replies with either an RAR Reply Message to BCAS or an RAR Busy Message to BCAS (5.2.3.2.3).

4.3.2.1 RAR Reply Message to BCAS

An RAR Reply Message to BCAS uses the long special surveillance reply, DF=16, with the MV field containing the subfields specified in 3.3.2.8.1.

Note.—Even though an RAR Reply Message is sent in response to receipt of a Resolution Message, the RAR information in the reply is not used. The reply serves only as a technical acknowledgment.

4.3.2.2 RAR Busy Message to BCAS

An RAR Busy Message to BCAS uses the long special surveillance reply, DF=16, with the MV field containing the subfields specified in 3.3.2.8.2.

4.4 Coordination With Ground ATARS Equipment

Note.—This section describes the coordination interactions between an airborne BCAS equipment and DABS ground sensors with ATARS.

4.4.1 ATARS Coordination Interrogations

When ATARS has determined that a BCAS aircraft requires a resolution advisory to resolve a collision conflict with one or more threat aircraft, an ATARS Resolution Advisory Message is uplinked via the DABS transponder to the RAR of the BCAS aircraft. In addition, for all ATCRBS aircraft in the near vicinity of a BCAS aircraft, ATARS

transmits positional information to BCAS in an ATCRBS Track Block Message. A separate ATCRBS Track Block Message is sent for each such ATCRBS aircraft.

Note.—ATARS ATCRBS track block are correlated with surveillance data for ATCRBS threats detected by BCAS. If the track block and the surveillance data correlate, BCAS defers resolution of the conflict to ATARS (5.2.1.2.2). This process reduces the number of unnecessary alerts generated by BCAS.

4.4.1.1 ATARS Resolution Advisory Message

An ATARS Resolution Advisory Message uses a Comm-A interrogation, UF=20 or 21, with the MA field containing the subfields specified in 3.3.2.3.1. Accompanying each ATARS Resolution Advisory Message is a downlink request for the RAR content of the BCAS aircraft. The ground sensor intiates this RAR downlink request by inserting RR=19 in the RR field of the Comm-A used for the ATARS resolution advisory.

4.4.1.2 ATCRBS Track Block Message

An ATCRBS Track Block Message uses a Comm-A interrogation, UF=20 or 21, with the MA field containing the subfields specified in 3.3.2.3.2.

4.4.2 Coordination Replies to ATARS

For coordination, ground ATARS equipment may request the RAR content of the BCAS aircraft by setting RR=19 in a surveillance or Comm-A interrogation, UF=4,5,20,21. When these requests are received via the DABS transponder, BCAS replies with an RAR Reply Message to ATARS or an RAR Busy Message to ATARS (5.2.3.3).

4.4.2.1 RAR Reply Message to ATARS

An RAR Reply Message to ATARS uses a Comm-B reply, DF=20 or 21, with the MB field containing the subfields specified in 3.3.2.4.1.

4.4.2.2 RAR Busy Message to ATARS

An RAR Busy Message to ATARS uses a Comm-B reply, DF=20 or 21, with the MB field containing the subfields specified in 3.3.2.4.2.

4.4.3 Extended Capability Report

The presence of operating Active BCAS equipment on board an aircraft causes the CA=2 code (extended capability) to be set in all DABS All-Call replies, DF=11, to the ground sensor (ref B: 3.3.6). The ground sensor learns of the specific extended capabilities on board the aircraft by using the extended capability report protocol specified in ref. B: 4.6.3. An Active BCAS on board the aircraft causes the following codes to be set in the MB subfields of an extended capability message (3.3.1.11.2, 3.3.2.4.3):

ACS: bit 46=1 (ATARS ATCRBS track blocks), bit 48=1 (ATARS resolution advisory/RAR)
ARC=2 (Active BCAS)
ECS: bit 72=1 (Extended Capability), bit 74=1 (RAR).

4.4.4 RAR Downlink Request

BCAS signals to the ATARS ground sensor if one or more of the bits in the RAR bit matrix is set to "1" (RAR not empty), to initiate transmission of the RAR to ground ATARS. Whenever a non-empty RAR exists, the DR field in a surveillance or Comm-B reply, DF=4,5,20,21, is set to DR=2 (RAR bit set) or DR=3 (RAR bit set and B-bit set) as appropriate.

4.4.5 BCAS Sensitivity Level Control

BCAS sensitivity level control by ground ATARS equipment is accomplished by the transmission of a surveillance or Comm-A interrogation, UF=4,5,20,21, in which DI=2 (SD contains ATARS information) and the appropriate sensitivity level command is set in the SLC subfield (3.3.2.10.1) of the corresponding SD field. The ATARS site ID information required to correlate the sensitivity level command with a given ATARS site is contained in the AIS subfield (3.3.1.17.1) of the same SD field.

4.5 Coordination With Ground RBX Equipment

Note.—This section describes the interactions between BCAS and RBX required for automatic control of the BCAS sensitivity level and for the transfer of displayed resolution advisories to ATC. Airborne BCAS equipments within the RBX range threshold regularly communicate with ground RBX equipment in order to determine range to the RBX and to transmit this information along with altitude and displayed resolution advisories. RBX replies to BCAS contain sensitivity level commands to BCAS.

4.5.1 RBX–BCAS Transmission Waveforms

All transmissions between the BCAS-equipped aircraft and the ground RBX equipment use the 1030 MHz DABS interrogation waveform (ref. B: 2.1). The SLS control pulse P5 is not transmitted.

4.5.2 RBX Squitter

Note.—Ground RBX units transmit squitters (unsolicited replies) at a regular rate to facilitate acquisition by the BCAS-equipped aircraft.

4.5.2.1 Squitter Acceptance

An RBX squitter is accepted, evaluated and acted upon by the DABS transponder in accordance with the criteria defined for interrogations with UF=6 (ref. B: 4.2.2.3.2). UF=6 identifies the transmission as originating from an RBX. RD=1 identifies the transmission as an RBX squitter. The RBX squitter contains a broadcast address, that is, all ones, in the AP field.

4.5.3 RBX Reply

4.5.3.1 Reply Acceptance

An RBX reply is accepted, evaluated and acted upon by the DABS transponder in accordance with the criteria defined for interrogations with UF=6 (ref. B: 4.2.2.3.2). UF=6 identifies the transmission as originating from an RBX. RD=2 identifies the transmission as an RBX reply. The RBX reply contains the discrete address of the interrogating BCAS aircraft in the AP field. The SLC subfield contains the sensitivity level command. The RTR subfield contains the range threshold value to indicate the radius within which the BCAS aircraft is required to maintain continuous track of the RBX.

4.5.3.2 Reply Delay and Jitter

The sync phase reversal of the P6 pulse in the RBX reply waveform occurs 500 ± 0.25 μsec after receipt of the sync phase reversal of the BCAS interrogation waveform. The jitter of the RBX reply delay does not exceed 0.05 μsec, rms.

4.5.4 BCAS to RBX Interrogation

The response to an accepted squitter (4.5.2.1) from an RBX with which BCAS is not currently communicating is a discrete interrogation with UF=22 and GD=1 (3.3.2.2). This is a range acquisition interrogation which contains a range field RAN of all ones. This and all subsequent interrogations to the RBX contain any currently displayed resolution advisory in the DRA field and the ATCRBS ID code in the AID field. When the range threshold value (RTR), the RBX range, and the BCAS maximum speed capability indicate that the BCAS aircraft has already penetrated or could soon penetrate the RBX range threshold, BCAS establishes and maintains communication with the RBX by discrete interrogations at 4-second intervals with UF=22 and GD=1. These interrogations contain RBX–BCAS range estimates based on the previous reply. They also contain the last sensitivity level command received from the RBX. If the BCAS aircraft could not soon penetrate the range threshold, interrogations to the RBX are temporarily suspended.

5. Characteristics of Airborne BCAS Equipment

5.1 Interference Control

5.1.1 RF Peak Output Power

The peak RMS output power of each pulse of a BCAS airborne transmission, measured at the terminals of the antenna, is less than or equal to 27 dBW.

5.1.1.1 Unwanted Output Power

When the airborne BCAS equipment is not transmitting an interrogation, the RF output power at the terminals of the antenna does not exceed –50 dBm at any frequency.

5.1.2 Interference Limiting

An airborne BCAS unit counts the number of other BCAS-equipped aircraft within detection range by noting the number of DABS replies and squitters (DF=4) which have FS=1 and different DABS address codes. If necessary, BCAS controls own surveillance transmissions so that the BCAS interrogations received at any point in space by an ATCRBS transponder do not materially reduce the transponder reply probability. Specifically, the interrogation rate or power, or both, of an airborne BCAS unit are adjusted, as necessary, to hold the following inequality true:

$$\frac{(\beta * 10^{\alpha}) + 1}{250} * ((D * P_D) + (S * \sum_{i=1}^{n} P_i)) \text{ .LE. } 570$$

Where:

α=(MTL + 74)/10

β=number of interrogating BCAS aircraft detected by squitter reception.

MTL=1090-MHz receiver threshold for squitter reception (dBm referred to antenna)

D=DABS interrogation rate (per sec)

P_D=DABS-mode interrogation peak power (watts referred to antenna)

S=ATCRBS-mode scan rate (sequences/sec)

n=number of interrogations in an ATCRBS interrogation sequence within one scan. If whisper-shout (4.1.1.2) is used, an ATCRBS suppression pair followed by an ATCRBS-only All-Call interrogation is counted as a single interrogation.

P_i=peak power of the i-th ATCRBS interrogation (watts referred to antenna)

Note.—Typical values are MTL=–74 dBm, P_D=250 watts, S=1 scan/sec., and, for the example whisper-shout sequence shown in Fig. 4.1–1, n=8. For an airborne BCAS that does not use whisper-shout, typically n=2 (one interrogation from the top antenna and one from the bottom). Interrogation limiting is very rarely invoked. When interrogation limiting is not invoked the overall ATCRBS and DABS interrogation rates are as follows: The ATCRBS interrogation rate (independent of traffic environment) is typically 8 per second. The DABS interrogation rate depends on the number of DABS-equipped aircraft in the vicinity and is very small when flying in airspace of low traffic density. When there are 6 DABS-equipped aircraft within 10 nmi, the interrogation rate is typically 6 to 18 DABS interrogations per second.

5.1.3 Interrogation Rate Jitter

The time interval between successive interrogation or groups of interrogations from an airborne BCAS unit varies sufficiently to preclude synchronous interference with other equipment.

5.1.4 Suppression of Own Aircraft Transponder

The DABS transponder on board the aircraft is suppressed during each BCAS transmission. The suppression interval is 250 ± 50 microsecond beginning at the time of the first pulse of the BCAS transmission.

Note.—The purpose of this suppression is to assure that the BCAS does not interrogate its own transponder.

5.2 Collision Avoidance Algorithms

BCAS airborne equipments contain algorithms that implement the following functions as illustrated in Figure 5.2–1.

a. Surveillance.
b. Tracking.
c. Threat Detection.
d. Resolution.
e. Communication and Coordination.

Certain of these functions or subfunctions must be standardized to ensure that the airborne BCAS units interface satisfactorily with each other, with ATARS, and with the conventional air traffic control (ATC) system. Parameters used in the algorithms are adjusted automatically to maintain collision avoidance protection with minimal interference to normal ATC operations. Each of the functions or subfunctions which is standardized is discussed in a paragraph below.

5.2.1 Threat Detection

All aircraft which are tracked by BCAS are considered intruders and potential collision threats. The characteristics of an intruder which are used to define a threat are:

BILLING CODE 4910-13-M

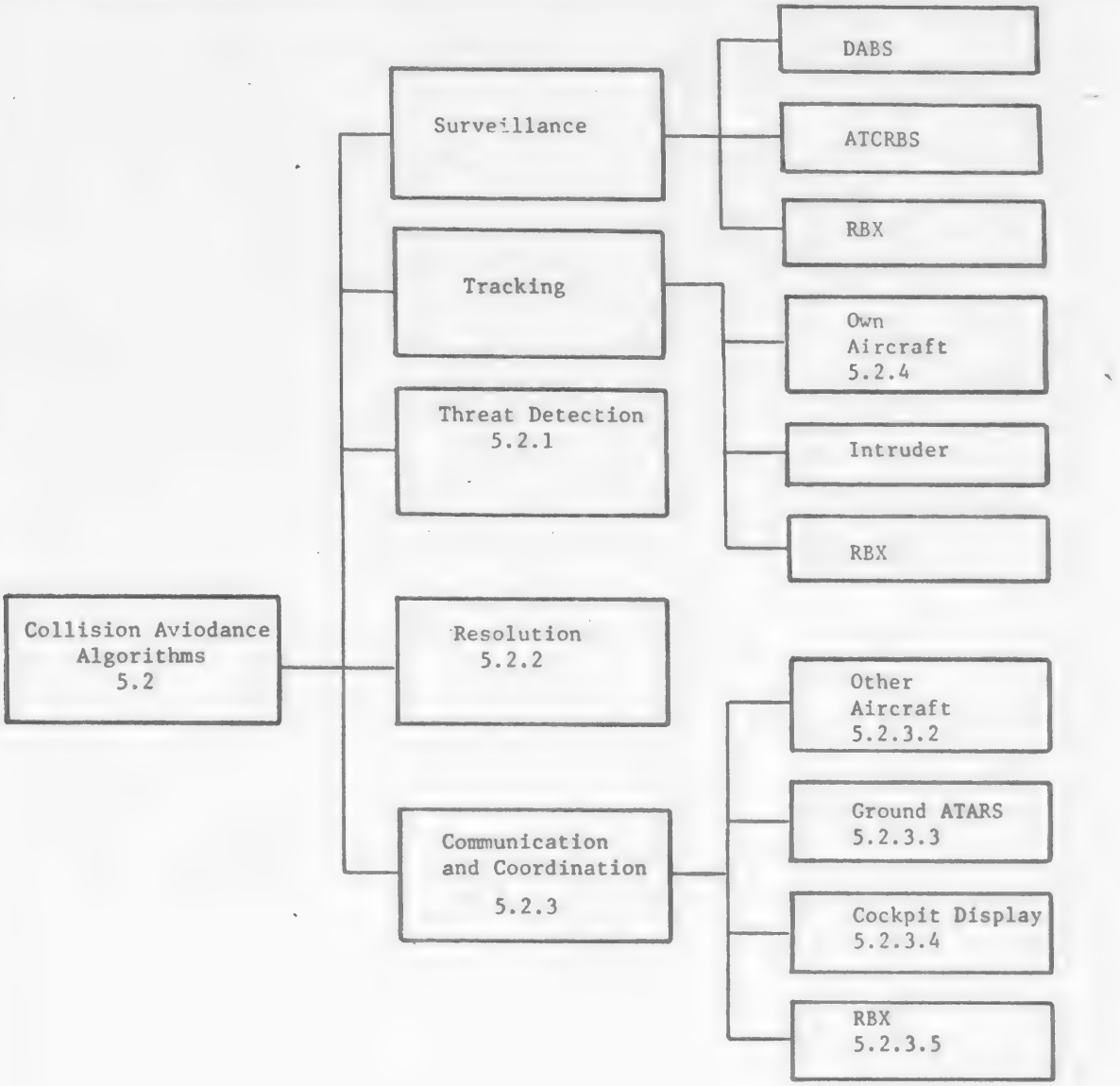

Figure 5.2-1. Functional Elements of BCAS Collision Avoidance Algorithms.

BILLING CODE 4910-13-C

Altitude—ZINT.
Rate of Change in Altitude—ZDINT.
Slant Range—R.
Rate of Change in Slant Range—RD.
BCAS Equipage (yes or no)—BEQ
Sensitivity Level of BCAS Operation—SLINT.
ATARS Coverage (yes or no) (4 entries)—ACINT(4).

BEQ is "YES" only if the intruder is equipped with BCAS and its resolution function is not inhibited (5.2.1.2.1). In addition, the following characteristics of the BCAS aircraft are used in threat definition:

Altitude—ZOWN.
Rate of Change in Altitude—ZDOWN.
Sensitivity Level of BCAS Operation—SLOWN.
ATARS Coverage (yes or no) (4 entries)—ACOWN(4).

Notes.—All altitudes are measured relative to 29.92 inches of mercury.

5.2.1.1 Parameter Selection

Calculations defining threats use parameter values (Table 5.2–1) which are selected based on the above characteristics.

5.2.1.2 Definition of Threat

BCAS evaluates each intruder through a prescribed sequence of tests to declare the intruder either a threat or a non-threat. BCAS generates resolution advisories (5.2.2) for all intruders declared threats.

Note.—BCAS does not generate resolution advisories for non-threats. However ATARS may, and BCAS coordinates and displays such advisories (5.2.3.3).

5.2.1.2.1 BCAS Resolution Status

The first test is to determine whether or not BCAS resolution of threats is inhibited. If BCAS resolution is inhibited, the intruder is a non-threat. Otherwise, the test of BCAS responsibility (5.2.1.2.2) is performed. BCAS resolution is inhibited when its sensitivity level (SLOWN, 5.2.4) is either "2" (Resolution Inhibited) or "1" (Interrogation of Aircraft Inhibited).

5.2.1.2.2 BCAS Responsibility

If BCAS is not responsible for the intruder, the intruder is a non-threat. Otherwise, the test of range divergence (5.2.1.2.3) is performed. BCAS is not responsible if both the intruder and BCAS are within coverage of the same ATARS site (have one or more common ATARS identity bits set). Thus if ACOWN(bit).EQ.1 and ACINT(bit).EQ.1 for any one common bit position, the intruder is declared a non-threat.

BILLING CODE 4910–13–M

TABLE 5.2-1

PARAMETERS USED IN THREAT DEFINITION

Parameter	BEQ is 'YES'					BEQ is 'NO'				
	MAX (SLINT,SLOWN)					MAX (SLINT,SLOWN)				
	3	4	5	6	7	3	4	5	6	7
DMOD NMI	0.075	0.1	0.3	1.0	1.3	0.075	0.1	0.3	1.0	1.3
TAU s	16	18	25	30	35	18	20	25	30	35
TVPCMD s	35	40		45	48	35	40		45	48
H1 NMI^2/s	0.002	0.00278			0.004	0.002	0.00278			0.004
ZTHR	See below									

ZOWN FT	ZTHR FT
less than 18,000	750
18,000 to 30,000	850
greater than 30,000	950

BILLING CODE 4910-13-C

ACINT for an ATCRBS-equipped intruder is determined through spatial correlation of intruder characteristics with ATCRBS track blocks (4.4.1.2).

5.2.1.2.3 Range Divergence

If the intruder range is diverging, the divergence hyperbola test (5.2.1.2.3.1) is performed. Otherwise, the test of time to range convergence (5.2.1.2.4) is performed. The range is diverging if RD is positive.

5.2.1.2.3.1 Divergence Hyperbola

If R*RD.LE.H1, the test of current range separation (5.2.1.2.3.2) is performed. Otherwise, the intruder is a non-threat.

5.2.1.2.3.2 Current Range Separation

If R.GT.DMOD, the intruder is a non-threat. Otherwise, the test of current altitude separation (5.2.1.2.5) is performed.

5.2.1.2.4 Time to Range Convergence

If (R–DMOD).GT.(TAU)*(-RD), the intruder is a non-threat. Otherwise, the test of current altitude separation (5.2.1.2.5) is performed.

5.2.1.2.5 Current Altitude Separation

If ABS(ZOWN–ZINT).GE.ZTHR, the test of altitude convergence (5.2.1.2.5.1) is performed. Otherwise, the test of vertical miss distance (5.2.1.2.6) is performed.

5.2.1.2.5.1 Altitude Covergence

If (ZOWN–ZINT) and (ZDINT-ZDOWN) have the same sign, altitude separation is decreasing and the test of time to altitude covergence (5.2.1.2.5.2) is performed. Otherwise, the intruder is a non-threat.

5.2.1.2.5.2 Time to Altitude Convergence

If ((ZOWN–ZINT)/(ZDINT–ZDOWN)).GT.TAU, the intruder is a non-threat. Otherwise, the test of vertical miss distance (5.2.1.2.6) is performed.

5.2.1.2.6 Vertical Miss Distance

If the projected vertical miss distance is small, the intruder is a threat. Otherwise, the test of range at co-altitude (5.2.1.2.7) is performed. The projected vertical miss distance is small if ABS((ZOWN–ZINT) +((ZDOWN–ZDINT)*TRTRU)).LE.ZTHR, where TRTRU=MIN(ABS(R/RD),TVPCMD) for RD.LT.O. If RD.GE.O, TRTRU=O.

5.2.1.2.7 Range at Co-Altitude

If altitude separation is decreasing (5.2.1.2.5.1) and the projected range at the time of co-altitude is small, the intruder is a threat. Otherwise, the intruder is a non-threat. The projected range at the time of co-altitude is small if ABS(R+(RD*TAUV)).LT.DMOD, where TAUV=(ZOWN–ZINT)/ZDINT–ZDOWN).

5.2.2 Computation of Resolution Advisories

BCAS considers the advisory options of Table 5.2–2 in resolving collision threats. Each threat is processed individually for selection of a resolution advisory. The sequence of resolution processing is as follows: a. Lock RAR (5.2.3.1).

b. Communicate with new threat (5.2.3.2.1).

c. Select sense of advisory for new threat (5.2.2.1).

d. Select magnitude of advisory (5.2.2.2).

e. Evaluate multi-aircraft situation (5.2.2.3).

f. Update RAR (5.2.3.1.1).

g. Unlock RAR (5.2.3.1).

h. Communicate with threat (5.2.3.2.2).

Note.—Items (a), (f), (g), and (h) of this sequence are also executed once for each newly declared non-threat that was previously a threat.

5.2.2.1 Selection of Sense

When an intruder is first declared a threat, BCAS selects the sense (climb or descend) of the maneuver. This sense selection remains unchanged throughout the encounter.

BCAS evaluates maneuver options by modeling the corresponding altitude separations after an escape maneuver at time of closest approach TESC, where TESC=MIN(ABS(R/RD),TVPESC); (Table 5.2–3). Options which imply vertical rates inconsistent with the current composite resolution advisory (5.2.3.4) are not modeled. Climbs and descents are modeled at nominal rates of 1000 FPM unless the current rate exceeds that magnitude, in which case the current rate is used. BCAS provisionally selects the sense of the maneuver which yields the greater altitude separation. If the threat is unequipped (BEQ is "NO") and the difference in separation resulting from a climb maneuver versus separation resulting from a descend maneuver is small (e.g. 150 ft or less), BCAS notes that its provisional sense selection is not significant.

5.2.2.1.1 Exception for Threats in a Multi-Aircraft Conflict

If the threat is BCAS-equipped (BEQ is "YES") and is in a multi-aircraft conflict, if own BCAS is not in a multi-aircraft conflict, and if own BCAS has received a message conveying maneuver sense from the threat BCAS (5.2.3.2.3), own BCAS selects the sense oposite that selected by the threat. Otherwise, BCAS makes no exception for multi-aircraft conflict conditions in selecting the sense of the resolution advisory other than that provide in 5.2.2.3.

Table 5.2–2.—*Resolution Advisory Options*

Down Sense	Up sense
Positive Advisories	
Descend	Climb.
Vertical Speed Minimums	
Descend faster than 500 FPM.	Climb faster than 500 FPM.
Descend faster than 1,000 FPM.	Climb faster than 1,000 FPM.
Descend faster than 2,000 FPM.	Climb faster than 2,000 FPM.
Negative Advisories	
Don't climb.	Don't descend.
Vertical Speed Limits	
Don't climb faster than 500 FPM.	Don't descend faster than 500 FPM.
Don't climb faster than 1,000 FPM.	Don't descend faster than 1,000 FPM.
Don't climb faster than 2,000 FPM.	Don't descend faster than 2,000 FPM.

TABLE 5.2-3

PARAMETER USED IN RESOLUTION ADVISORY SELECTION

PARAMETER	MAX (SLINT, SLOWN)				
	3	4	5	6	7
TVPESC s	25	30	30	35	40
ALIM	See below				

ZOWN FT	ALIM FT
less than 10,000	340
10,000 to 18,000	440
18,000 to 30,000	640
greater than 30,000	740

5.2.2.1.2 Yielding to Prior Sense Selection by Threat

If the threat has already selected and communicated a vertical sense selection to BCAS, BCAS selects the sense opposite to that selected by the threat if the corresponding altitude separation at the time of closest approach (TESC, 5.2.2.1) is greater than 400 ft.

5.2.2.1.3 Path Prediction

BCAS models its own and the threat's trajectory based on threat's displayed resolution advisory (5.2.3.5.2) and own vertical maneuver options. The model of each aircraft's altitude profile is a projection with one maneuver at constant acceleration to a new altitude rate (equations below).

If the threat's current altitude rate (ZDINT) satisfies the displayed resolution advisory obtained from its RAR, the threat is modeled as continuing at its current altitude rate. Otherwise, the threat is modeled as accelerating to a rate which satisfies its displayed resolution advisory with minimum change in vertical rate.

If TCUR.LT.T.LE.DELAY+TCUR,
Z(T)=Z(TCUR)+(ZD(TCUR)
*(T−TCUR))
If
DELAY+TCUR.LT.T.LE.DELAY+TCUR
+(ABS(SE
NSE*ZDGOAL−ZD(TCUR))/VACCEL),
Z(T)=Z(TCUR)+(ZD(TCUR)
*(T−TCUR))+
(SENSE*.5*VACCEL
*(T−DELAY−TCUR)²)
,
If
T.GT.DELAY+TCUR+(ABS((SENSE
*ZDGOAL)−Z
D(TCUR))/VACCELL),
Z(T)=Z(TCUR)+(ZD(TCUR)*(DELAY
+(ABS((S
ENSE*ZDGOAL)−ZD(TCUR))/
VACCEL)))+(SENSE*.5*VACCEL
*(ABS((SENSE*ZDGOAL)−
ZD(TCUR))/VACCEL)²)+((T−DELAY−
TCUR−(ABS((SENSE*ZDGOAL)−
ZD(TCUR))/
VACCEL))*ZDGOAL*SENSE).
TCUR=Current Time
T=Time of Prediction
DELAY=Pilot Response Time
(=5 Sec for New Advisories)
(=1 Sec for Changed Advisories)
Z(X)=Altitude at time X
ZD(X)=Altitude Rate at Time X
ZDGOAL=Altitude Rate Objective of
Resolution Advisory
(=MAX(1000 FPM,ABS(ZDOWN)) for
Positive Advisories)
(=0 FPM for Negative Advisories)
(=−500 FPM: if ABS(VSL)=500)
(=−1000 FPM: if ABS(VSL)=1000)
(=−2000 FMP: if ABS(VSL)=2000)
SENSE=Sense Selection
(=+1 for "Up" Sense)
(=−1 for "Down" Sense)
VACCEL=Acceleration Rate
(=8 FPS²)

5.2.2.2 Selection of Advisory Magnitude

BCAS selects a resolution advisory which results in a predicted safe altitude separation at time of closest approach (TESC, 5.2.2.1) with the least impact on the current flight path by following the sequence of tests described below. Certain parameter values used in the prediction of safe altitude separation are selected based on the characteristics of own and threat aircraft.

5.2.2.2.1 Current Altitude Separation

The first test is to determine whether or not the current altitude separation is small. If the current altitude separation is small, the test of predicted altitude separation (5.2.2.2.2) is performed. Otherwise, the test of threat equipage (5.2.2.2.2.1) is performed. The current altitude separation is small if ABS (ZOWN−ZINT).LT.ALIM.

5.2.2.2.2 Predicted Altitude Separation

If the predicted altitude separation is small, a positive advisory of the established sense (5.2.2.1) is selected. Otherise, the test of extension of own vertical rate (5.2.2.2.3) is performed. The predicted altitude separation is small if ABS((ZOWN−ZINT) + ((ZDOWN−ZDINT)* TRUTRU)).LT.ALIM, where TRTRU=MIN(ABS(R/RD), TVPCMD).

5.2.2.2.2 Threat Equipage

If BEQ is "YES", the test of extension of own vertical rate (5.2.2.2.3) is performed. Otherwise, the test of threat altitude rate (5.2.2.2.2.2) is performed.

5.2.2.2.2.2 Threat Altitude Rate

If threat has no vertical rate (ZDINT near zero), the test of extension of own vertical rate (5.2.2.2.3) is performed. Otherwise, the test of predicted altitude separation (5.2.2.2.2) is peformed.

5.2.2.2.3 Extension of Own Vertical Rate

If extending own vertical rate will resolve the encounter, the vertical speed minimum test (5.2.2.2.3.1) is performed. Otherwise, the vertical speed limit test (5.2.2.2.4) is performed. Extending own vertical rate will resolve the encounter if the predicted vertical separation (5.2.2.1.3) at time TESC (5.2.2.1) is greater in magnitude than ALIM for all rates in the direction of ZDOWN (5.2.1) that are equal to or which exceed the magnitude of ZDOWN.

5.2.2.2.3.1 Vertical Speed Minimum

BCAS selects the lowest magnitude Vertical Speed Minimum (Table 5.2–2) which provides a vertical rate for own BCAS resulting in a predicted vertical separation (5.2.2.1.3) at time TESC (5.2.2.1) greater in magnitude than ALIM. If no such Vertical Speed Minimum exists, BCAS selects a positive advisory of the established sense (5.2.2.1).

5.2.2.2.4 Vertical Speed Limit

BCAS selects the highest magnitude Vertical Speed Limit (Table 5.2–2) that provides a vertical rate for own BCAS resulting in a predicted vertical separation (5.2.2.1.3) at time TESC (5.2.2.1) greater in magnitude than ALIM. If the lowest magnitude Vertical Speed Limit does not result in a predicted vertical separation at time TESC greater in magnitude than ALIM, BCAS selects a negative advisory of the established sense (5.2.2.1).

5.2.2.3 Multi-Aircraft Conflicts

BCAS converts existing resolution advisories as illustrated in Table 5.2–4 when it determines that own BCAS has more than one simultaneous threat. Sense selections which were noted to be not significant (5.2.2.1) do not constrain multi-aircraft resolution advisory selection, and may be changed as a result of multi-aircraft resolution. After conversion, all resolution advisories have significant sense.

5.2.3 Communication

BCAS airborne equipments communicate with BCAS aircraft, with ATARS aircraft, and with ATARS and RBX ground stations. The principal interface for these communications is the Resolution Advisory Register (RAR), illustrated by Figure 5.2–2. The RAR stores all current resolution advisories by source using a single bit to indicate which advisory components have been established by which source.

5.2.3.1 RAR Management

Access to the RAR is limited to one user at a time. This user may be own aircraft, a threat BCAS, or an ATARS ground site. To ensure that the RAR is not accessed while it is in the process of being updated, BCAS excludes any user other than the updating user from communicating with its RAR (except as provided in 5.2.3.2.3). That is, BCAS locks out all other users for the duration of the update. In order to protect against extended RAR lock intervals due to communications failures, the maximum duration of any RAR lock is 0.1 seconds.

5.2.3.1.1 Update RAR With Own BCAS Advisories

All advisories selected by own BCAS to resolve conflicts for which own BCAS is responsible are posted in the "Own BCAS" column of the RAR (Figure 5.2–2). A vertical speed minimum is stored

as a positive advisory of the same sense. The column is updated each time an advisory is added (new threat resolved) or an advisory for an existing threat is modified or deleted. If the current advisory for a threat is to be deleted, BCAS enters a "0" in the appropriate row of the RAR if that advisory is not also posted for another threat. If an advisory is to be added or refreshed for some threat, BCAS enters a "1" in the appropriate row of the RAR if a "1" is not already present. If an existing bit in the "Own BCAS" column is not refreshed within 6 seconds, it is set to "0".

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TABLE 5.2-4

CONVERSION OF RESOLUTION ADVISORIES

FOR MULTI-AIRCRAFT CONFLICTS

Existing Resolution Advisory		Converted Resolution Advisory			
Sense	Magnitude	No Significant 'UPWARD' or 'DOWNWARD' Sense Selections	One or More 'DOWNWARD' Sense Selections but No Significant 'UPWARD' Sense Selections	One or More 'UPWARD' Sense Selections but No Significant 'DOWNWARD' Sense Selections	Significant 'UPWARD' and 'DOWNWARD' Sense Selections
Upward	VSM	No Change	DESCEND	No Change	DON'T DESCEND
Upward	CLIMB	No Change	DESCEND	No Change	DON'T DESCEND
Upward	DON'T DESCEND	No Change	DESCEND	CLIMB	No Change
Upward	VSL	No Change	DESCEND	CLIMB	No Change
Downward	VSL	No Change	DESCEND	CLIMB	No Change
Downward	DON'T CLIMB	No Change	DESCEND	CLIMB	No Change
Downward	DESCEND	No Change	No Change	CLIMB	DON'T CLIMB
Downward	VSM	No Change	No Change	CLIMB	DON'T CLIMB

Each resolution advisory will be converted from the list on the left hand side to the advisory shown.

RAR BIT MATRIX
14 ROWS AND 6 COLUMNS
1 = ADVISORY ACTIVE
0 = ADVISORY NOT ACTIVE

	ATARS SITE A	ATARS SITE B	ATARS SITE C	ATARS SITE D	OWN BCAS	ALL OTHER BCAS
CLIMB						
DON'T DESCEND						
DON'T DESCEND FASTER THAN 500 FPM						
DON'T DESCEND FASTER THAN 1000 FPM						
DON'T DESCEND FASTER THAN 2000 FPM						
DESCEND						
DON'T CLIMB						
DON'T CLIMB FASTER THAN 500 FPM						
DON'T CLIMB FASTER THAN 1000 FPM						
DON'T CLIMB FASTER THAN 2000 FPM						
TURN LEFT						
TURN RIGHT						
DON'T TURN LEFT						
DON'T TURN RIGHT						

FIGURE 5.2-2. RESOLUTION ADVISORY REGISTER (RAR).

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5.2.3.1.2 Update RAR With Other BCAS Advisories

The advisory complements (Table 5.2–5) received from all other BCAS aircraft (5.2.3.2.2) are posted in the "All Other BCAS" column of the RAR (Figure 5.2–2). If there is a complement to delete (own BCAS dropped as a threat), BCAS enters a "0" in the appropriate row of the RAR if that complement is not also posted for another aircraft. If there is a complement to add or to be refreshed, BCAS enters a "1" in the appropriate row of the RAR if a "1" is not already present. If an existing bit in the "All Other BCAS" column is not refreshed within 6 seconds, it is set to "0".

5.2.3.1.3 Update RAR With ATARS Advisories

The first step in updating the RAR with a resolution advisory received from ATARS (4.4.1.1) is to write all zeroes received directly into the appropriate rows of the RAR column associated with that ATARS site. Then, all advisory components set to "1" are tested against the contents of the RAR (all columns) for compatibility (Figure 5.2–3). Any advisory component that is incompatible is not accepted. Any advisory component accepted is entered into the RAR as a "1" in the appropriate row. If the contents of any RAR column are not updated within 10 seconds, all bits in the column are set to "0".

5.2.3.2 Coordination With Other Aircraft

BCAS coordinates conflict resolution with other BCAS-equipped or ATARS-equipped aircraft (Figure 5.2–4).

5.2.3.2.1 Transmission of RAR Request Message

BCAS transmits the RAR Request Message (4.3.1.1) to a newly declared BCAS-equipped or ATARS-equipped threat and waits for a reply (4.3.2). If BCAS receives an RAR Busy Message (4.3.2.2), BCAS retransmits the RAR Request Message.

5.2.3.2.2 Transmission of Resolution Message

After selecting a resolution advisory for a threat, BCAS unlocks own RAR and then transmits the Resolution Message (4.3.1.2) to that threat. If BCAS receives an RAR Busy Message (4.3.2.2), BCAS retransmits the Resolution Message.

5.2.3.2.3 Coordination Reply to BCAS

If BCAS receives an RAR Request Message (4.3.1.1) from a BCAS aircraft and own RAR is not locked, BCAS locks the RAR for access only by the requestor and replies with an RAR Reply Message (4.3.2.1). If BCAS receives an RAR Request Message (4.3.1.1) while own RAR is locked to process the interrogating aircraft as a threat, and the DABS address code of the interrogating aircraft is less than the DABS address code of own BCAS, then own BCAS locks its RAR to deny access to all users other than the interrogating aircraft and replies with an RAR Reply Message (4.3.2.1). Otherwise, BCAS replies with an RAR Busy Message (4.3.2.2).

Table 5.2–5.—*Complements of Resolution Advisories*

Resolution Advisory	Complement
Climb faster than 500 FPM	Don't climb.
Climb faster than 1,000 FPM	Don't climb.
Climb faster than 2,000 FPM	Don't climb.
Climb	Don't climb.
Don't descend	Don't climb.
Don't descend faster than 500 FPM.	Don't climb.
Don't descend faster than 1,000 FPM.	Don't climb.
Don't descend faster than 2,000 FPM.	Don't climb.
Descend faster than 500 FPM.	Don't descend.
Descend faster than 1,000 FPM.	Don't descend.
Descend faster than 2,000 FPM.	Don't descend.
Descend	Don't descend.
Don't climb	Don't descend.
Don't climb faster than 500 FPM.	Don't descend.
Don't climb faster than 1,000 FPM.	Don't descend.
Don't climb faster than 2,000 FPM.	Don't descend.

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COMPATIBLE
RESOLUTION
ADVISORIES

1 = COMPATIBLE
0 = NOT COMPATIBLE

COMPATIBLE RESOLUTION ADVISORIES	CLIMB	DON'T DESCEND	DON'T DESCEND FASTER THAN 500 FPM	DON'T DESCEND FASTER THAN 1000 FPM	DON'T DESCEND FASTER THAN 2000 FPM	DESCEND	DON'T CLIMB	DON'T CLIMB FASTER THAN 500 FPM	DON'T CLIMB FASTER THAN 1000 FPM	DON'T CLIMB FASTER THAN 2000 FPM	TURN LEFT	TURN RIGHT	DON'T TURN LEFT	DON'T TURN RIGHT
CLIMB	1	1	1	1	1	0	0	0	0	0	1	1	1	1
DON'T DESCEND	1	1	1	1	1	0	1	1	1	1	1	1	1	1
DON'T DESCEND FASTER THAN 500 FPM	1	1	1	1	1	0	1	1	1	1	1	1	1	1
DON'T DESCEND FASTER THAN 1000 FPM	1	1	1	1	1	0	1	1	1	1	1	1	1	1
DON'T DESCEND FASTER THAN 2000 FPM	1	1	1	1	1	0	1	1	1	1	1	1	1	1
DESCEND	0	0	0	0	0	1	1	1	1	1	1	1	1	1
DON'T CLIMB	0	1	1	1	1	1	1	1	1	1	1	1	1	1
DON'T CLIMB FASTER THAN 500 FPM	0	1	1	1	1	1	1	1	1	1	1	1	1	1
DON'T CLIMB FASTER THAN 1000 FPM	0	1	1	1	1	1	1	1	1	1	1	1	1	1
DON'T CLIMB FASTER THAN 2000 FPM	0	1	1	1	1	1	1	1	1	1	1	1	1	1
TURN LEFT	1	1	1	1	1	1	1	1	1	1	1	0	0	1
TURN RIGHT	1	1	1	1	1	1	1	1	1	1	0	1	1	0
DON'T TURN LEFT	1	1	1	1	1	1	1	1	1	1	0	1	1	1
DON'T TURN RIGHT	1	1	1	1	1	1	1	1	1	1	1	0	1	1

Figure 5.2-3. ATARS Advisory Compatibility.

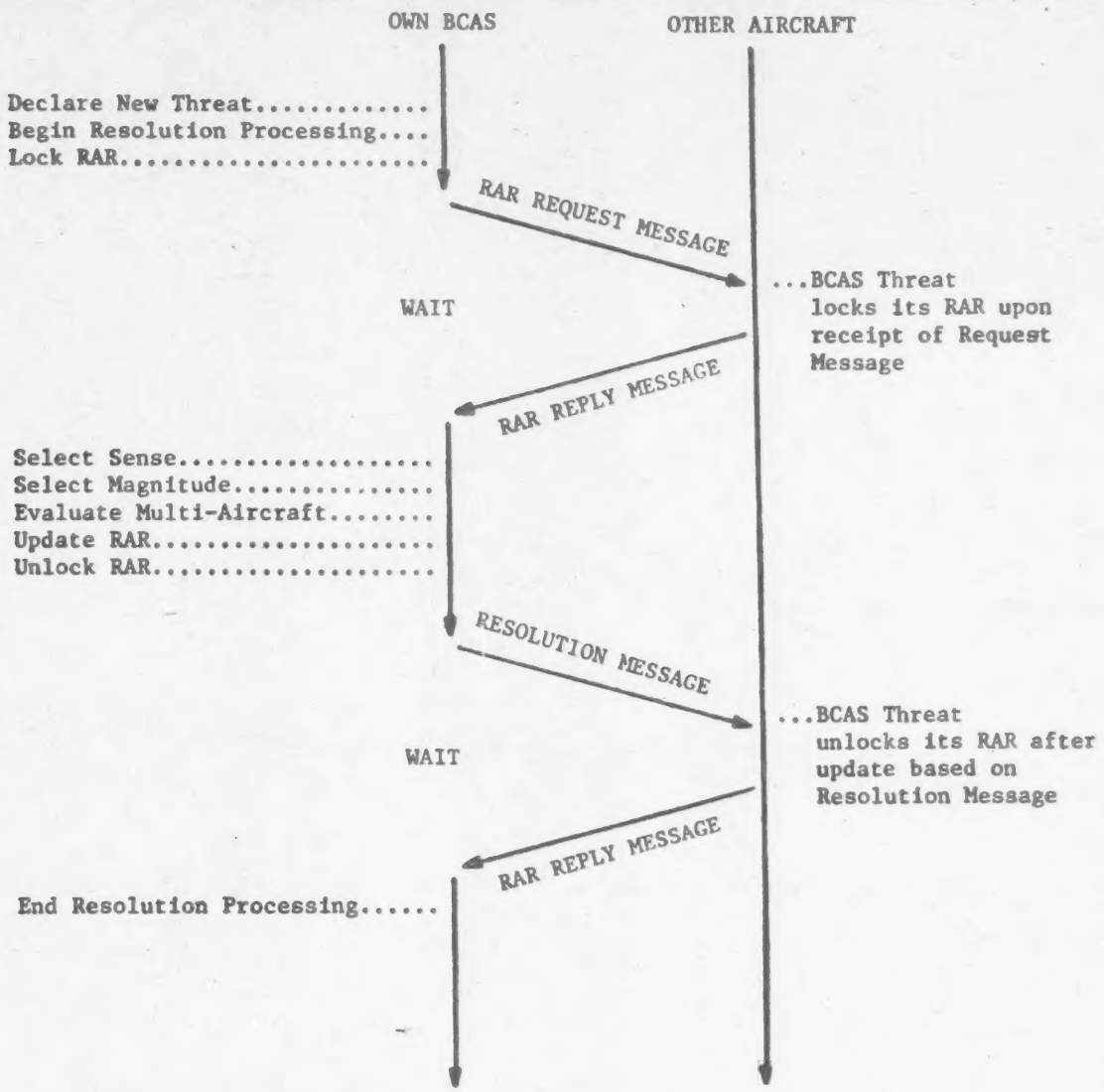

Figure 5.2-4a. Coordination With New Threat Aircraft.

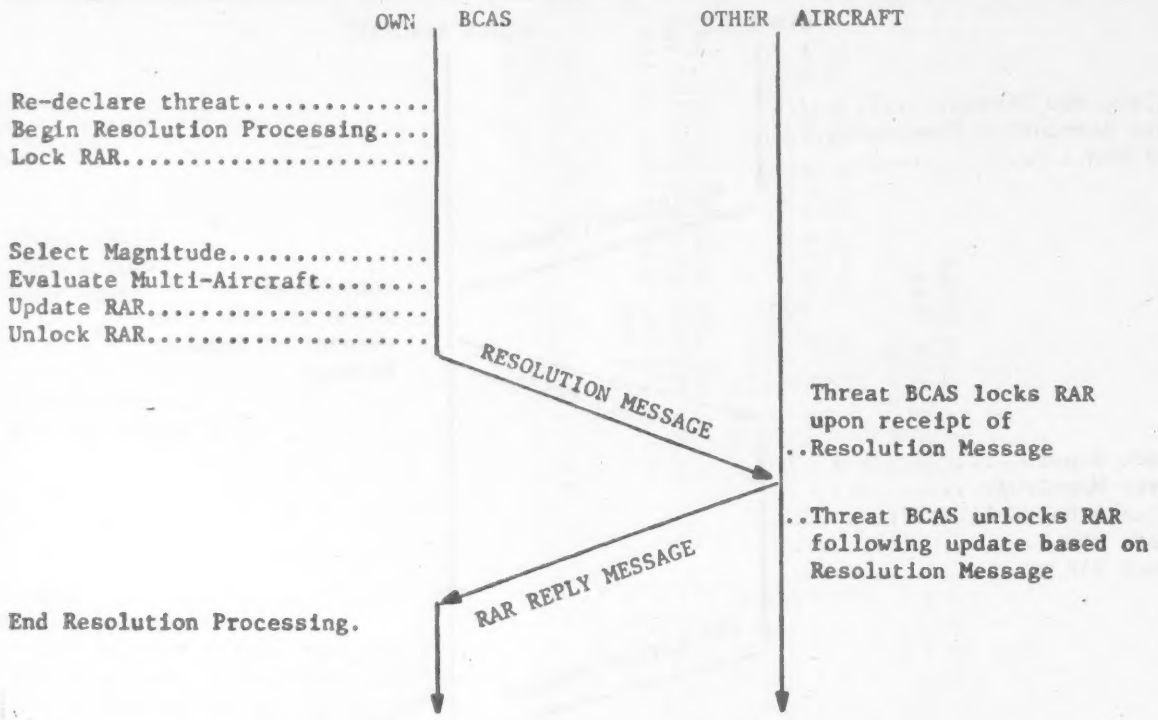

Figure 5.2-4b. Coordination with Established Threat Aircraft.

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Note.—If BCAS relinquishes access to its RAR in favor of an interrogating aircraft, BCAS reacquires access when the interrogating aircraft unlocks the BCAS RAR.

If BCAS receives a Resolution Message (4.3.1.2) and own RAR is not locked, BCAS locks own RAR for access only by the requestor, replies with an RAR Reply Message (4.3.2.1), updates own RAR (5.2.3.1.2) and then unlocks own RAR. If BCAS receives a Resolution Message (4.3.1.2) and own RAR is locked for access only by the interrogating BCAS, BCAS replies with an RAR Reply Message (4.3.2.1), updates own RAR (5.2.3.1.2) and then unlocks own RAR. Otherwise BCAS replies with an RAR Busy Message (4.3.2.2).

The RAR Reply Message to BCAS (4.3.2.1) contains an encoded image of each column of own RAR (3.3.2.8.1). The horizontal advisories of a column are encoded by scanning the "Left Component" list of Table 5.2–6 and selecting the first advisory contained in the column, and then scanning the "Right Component" list of Table 5.2–6 and selecting the first advisory contained in the column. The two horizontal components thus selected are then encoded in accordance with 3.3.2.8.1. The vertical advisories of a column are encoded using the same technique employed for encoding horizontal advisories except that the "Up Component" and "Down Component" lists of Table 5.2–6 are scanned.

5.2.3.3 Coordination With Ground ATARS Equipment

If BCAS receives an ATARS Resolution Advisory Message (4.4.1.1) and the RAR is not locked to deny access to the corresponding ground ATARS equipment, the RAR is locked to deny access to all other users, an RAR Reply Message (4.4.2.1) is transmitted, the RAR is updated (5.2.3.1.3), and the RAR is unlocked. Otherwise, an RAR Busy Message (4.4.2.2) is transmitted.

If BCAS receives a request from ground ATARS equipment to transmit RAR contents (RR=19, 4.4.2) and the request is not an ATARS Resolution Advisory Message, and if the RAR is not locked to deny access to the corresponding ATARS ground site, then the RAR is locked to deny access to all other users, an RAR Reply Message (4.4.2.1) is transmitted, and the RAR is unlocked. Otherwise, an RAR Busy Message (4.4.2.2) is transmitted.

The RAR Reply Message to ATARS (4.4.2.1) contains an encoded image of each column of own RAR (3.3.2.4.1). The horizontal and vertical advisories of each column are encoded using the technique employed for the RAR Reply Message to BCAS (5.2.3.2.3).

5.2.3.3.1 Command of Sensitivity Level From Ground ATARS Equipment

BCAS accepts a sensitivity level command from ground ATARS equipment (4.4.5). A sensitivity level command received from ATARS remains effective until replaced by the same site. If an existing command is not refreshed within 14 seconds, it is set to "0".

Table 5.2–6.—*Hierarchy of Resolution Advisories*

Left component	Right component
Turn left	Turn right.
Don't turn right	Don't turn left.
Up component	Down component.
climb	Descend.
climb faster than 2,000 FPM	Descend faster than 2,000 FPM.
climb faster than 1,000 FPM	Descend faster than 1,000 FPM.
Climb faster than 500 FPM	Descend faster than 500 FPM.
Don't descend	Don't climb.
Don't descend faster than 500 FPM.	Don't climb faster than 500 FPM.
Don't descend faster than 1,000 FPM.	Don't climb faster than 1,000 FPM.
Don't descend faster than 2,000 FPM.	Don't climb faster than 2,000 FPM.

5.2.3.4 Cockpit Display

To develop the composite resolution advisory output to the cockpit, BCAS scans the resolution advisories stored in the four ATARS columns of the RAR and the resolution advisories that own BCAS has generated for all threats for which it is responsible. A composite resolution advisory with up to four components is synthesized by selecting one or fewer advisories from each of the four lists in Table 5.2–6. An advisory, if any, is selected from each list by starting at the top of the list and selecting the first advisory that appears in any one of the ATARS columns or among the advisories generated by own BCAS.

Note 1.—An example of a four-component resolution advisory is "Don't Climb, Don't Descend, Don't Turn Right, Don't Turn Left."

Note 2.—The "Own BCAS" column of the RAR does not fully represent all advisories generated by own BCAS because Vertical Speed Minimum advisories are posted as positive advisories of the same sense. The "All Other BCAS" column is not used in synthesizing the composite resolution advisory.

5.2.3.5 Coordination With Ground RBX Equipment

BCAS communicates with any ground RBX equipment for which the range to the RBX is less than the range threshold for the RBX (4.5). BCAS accepts sensitivity level commands from each such RBX, and transmits displayed resolution advisories (5.2.3.5.2) to the RBX.

5.2.3.5.1 RBX Command of Sensitivity Levels

BCAS accepts sensitivity level commands from an RBX (4.5.3). A sensitivity level command received from an RBX remains effective until modified by the same RBX. If a command is not refreshed within 14 seconds, it is set to "0".

5.2.3.5.2 Displayed Resolution Advisory

The displayed resolution advisory is the composite resolution advisory derived from the four ATARS columns and the "Own BCAS" column of an RAR. The displayed resolution advisory transmitted to the RBX (4.5.4) is derived from own RAR. A displayed resolution advisory derived from the threat RAR is used for path prediction (5.2.2.1.3).

A displayed resolution advisory with up to four components is synthesized by selecting one or fewer advisories from each of the four lists in Table 5.2–6. An advisory, if any, is selected from each list by starting at the top of the list and selecting the first advisory that appears in any one of the four ATARS columns or in the "Own BCAS" column.

5.2.4 Selection of SLOWN

BCAS selects the lowest nonzero command as the value of SLOWN from all the current sensitivity level commands received from ground ATARS equipment (5.2.3.3.1) and ground RBX equipment (5.2.3.5.1). If there is no current nonzero command and ZOWN (5.2.1) is greater than 10,000 ft, SLOWN is selected as 7. Otherwise, SLOWN is selected as 5.

5.3 Interfaces

5.3.1 DABS Transponder Inputs

The following inputs to the DABS transponder are also input to the airborne BCAS equipment: a. ATCRBS Mode A (4096) code.

b. Altitude OFF signal.

c. On the ground signal.

d. DABS address code.

e. Own maximum operating airspeed code.

f. Pressure altitude.

Note.—The ATCRBS Mode A code and the altitude off input are from the DABS transponder control panel; the on the ground signal may be either from the control panel or from an automatic air-ground switch.

5.3.2 Additional Inputs

Additional inputs may be provided to the airborne BCAS equipment. For

example: a. A manual input for selection of sensitivity level.

b. An input signal from a radar altimeter which allows descend advisories to be inhibited at low altitudes and which permits automatic sensitivity level switching when in proximity to the ground.

c. Magnetic heading as provided by a directional gyroscope may be used with ATCRBS intruder bearing (as provided by a BCAS antenna with direction finding capability) for correlation with intruder bearing in ATCRBS track blocks by ground ATARS equipment (5.2.1.2.2).

5.4 Airborne Antenna System

A BCAS unit transmits interrogations and receives replies via two antennas, one top mounted and the other bottom mounted. These may be dedicated antennas or shared with other avionics.

Note.—A BCAS unit and DABS transponder may share a single pair of antennas.

5.4.1 Polarization

The antennas are vertically polarized.

5.4.2 Radiation Pattern

The radiation pattern of each antenna when installed on an aircraft is nominally equivalent to that of a quarter-wave monopole on a ground plane. This gives a nominal 3 dB vertical beamwidth of 30 degrees and an omnidirectional pattern in the horizontal plane.

Note.—Airborne BCAS equipment may use one or more antennas with direction finding capability and may use antennas with directional radiation patterns. If directional radiation patterns are employed, the antenna(s) must be so designed that BCAS surveillance is provided throughout the volume serviced by top and bottom mounted quarter-wave monopoles with antenna gains no less than that provided by the monopoles minus 3 dB.

5.4.3 Antenna Selection

5.4.3.1 Squitter Listening

A BCAS unit receives squitters via the top and bottom antennas. This can take the form of simultaneous reception using two receivers and two decoders or switched reception using one receiver. If reception is switched, the switching times are controlled to avoid undesirable synchronism with the squitters transmitted by DABS diversity transponders.

Note.—A DABS diversity transponder transmits squitters at the rate of nominally 1 each second alternating between its two antennas. An example of a switching pattern by which a BCAS unit can listen for squitters while avoiding undesirable sychronism is to switch receiving antennas once every 2 seconds; then in each 4-second period, squitters are transmitted/received via all four antenna pairs.

5.4.3.2 Interrogation

A BCAS unit transmits each ATCRBS or DABS interrogation via one or the other of the two antennas. Interrogations are not transmitted simultaneously via both antennas.

6. Characteristics of Ground RBX Equipment

6.1 Interference Control

6.1.1 RF Peak Effective Radiated Power

The maximum effective radiated peak power of any RBX squitter or reply pulse is +40 dBW including antenna gain and transmission loss.

6.1.2 Unwanted RF Output Power

When the RBX is not transmitting a squitter or reply, its output in the frequency band from 1027 to 1033 MHz does not exceed −35 dBW effective radiated power.

6.1.3 Squitter Rate

The squitter rate for a single RBX is one squitter every four seconds.

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